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The

Tropical Agriculturist

MAY, 1941

EDITORIAL

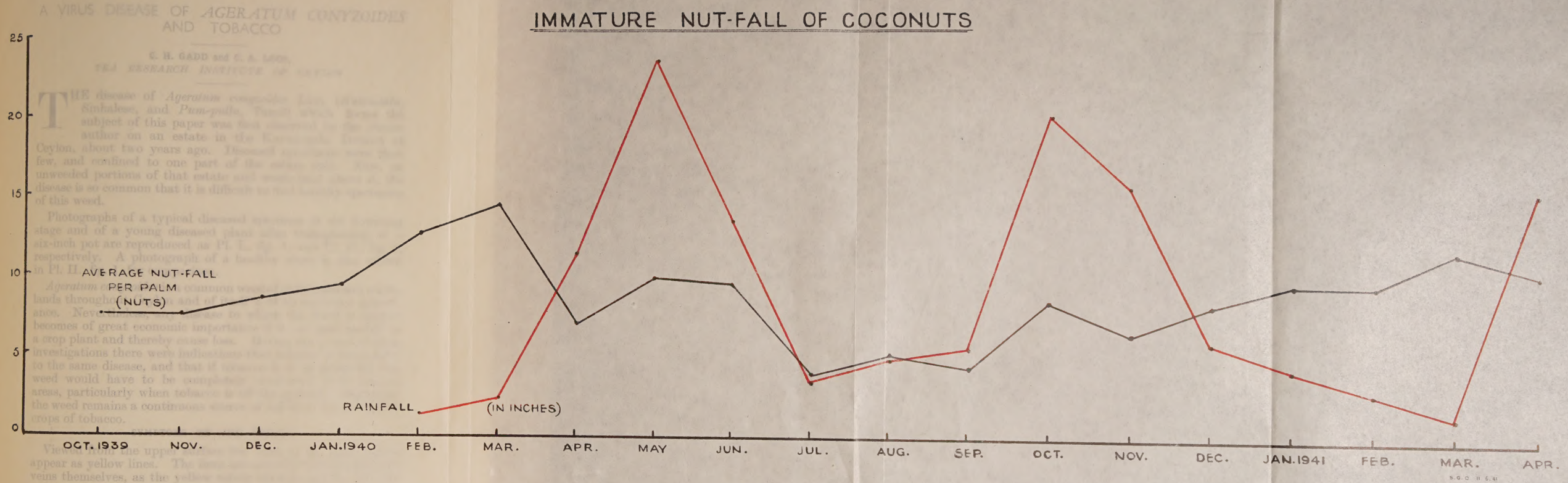
THE PREMATURE FALL OF COCONUTS

DIRECT physical injury to the bunch stalk or to the individual nut may cause the fall of the immature coconut. In these cases the cause is obvious. In most estates there is a certain number of trees which drop their nuts before maturity with no such apparent reason. When the industry was prosperous the planter was not disturbed by the loss of a small percentage of nuts from this cause ; but when low prices made it necessary for him to seek compensation in higher yields, he began to ask whether nothing could be done to stop this waste. One energetic planter practically forced the problem on the notice of the Department of Agriculture, which undertook certain investigations with his helpful co-operation. The publicity which the subject received from the discussion at a meeting of the Kurunegala Planters' Association in 1939 perhaps accelerated the pace of these investigations. They have so far been inconclusive and have not even provided an index to the future solution of the problem. The Department decided to publish the graph which appears on the next page not because it contains information which is immediately useful but because it was thought desirable to create interest in the subject and perhaps induce suggestions from the public on a problem which is probably more agricultural than scientific.

The average monthly falls of nuts per palm for all the trees in the observation areas are plotted in the graph side by side with the rainfall. The curve shoots up in the dry months January-March and the inference is drawn that the severity of the nutfall is due to physiological factors produced by inadequate soil moisture. But, confronted with the minor but not negligible peaks of the wet months of May and October, one proceeds to hypothesize that there are two parallel causes : inadequate moisture which reaches its highest intensity in the dry months and a fungus disease which is most active in wet weather. The symptoms pointed to *Phytophthora palmivora* as the offending organism. But efforts to isolate it by culture in the laboratory yielded negative results.

In these circumstances the empirical "hit or miss" method of experimentation was applied so as to cover the possibility of both an organic causal agent and unfavourable physical factors. Sulphur dusting, application of copper emulsion, cutting the lower leaves of the crown, improvement of soil drainage, special manures, application of salt to the soil, burning the crown without damaging the apical bud—all these forms of treatment were tried with no significant results. The drainage of the soil and the burning of the crown were followed by symptoms of recovery but after a short time the trees relapsed to their bad habit of dropping their nuts prematurely.

Perhaps it is appropriate that at this stage the Coconut Research Scheme should take up the investigation. In the meantime those who are engaged in it will find suggestions from experienced planters and other members of the public helpful. Even if such suggestions do not prescribe the cure, they may indicate new lines of inquiry.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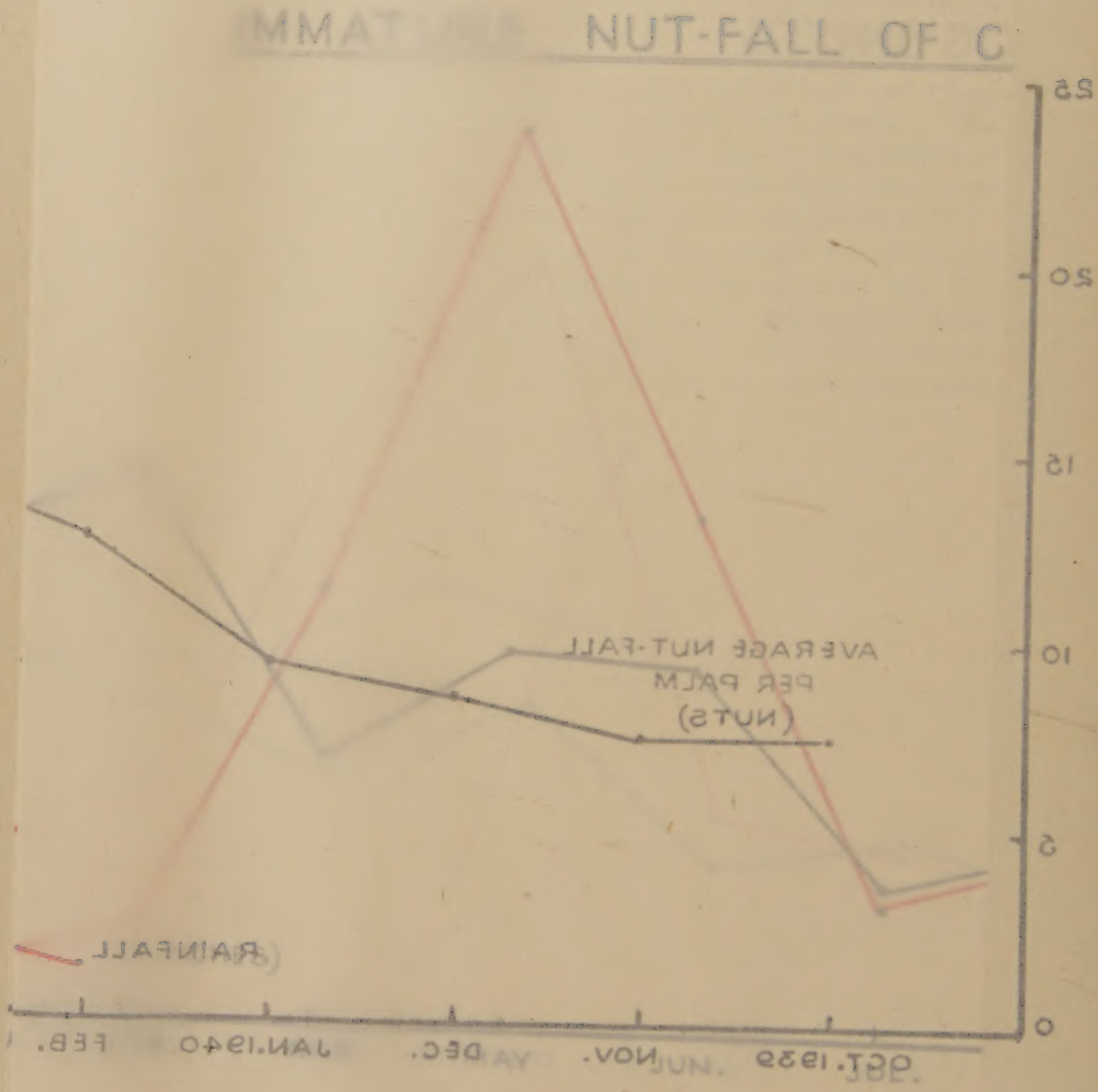
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A VIRUS DISEASE OF *AGERATUM CONYZOIDES* AND TOBACCO

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THE disease of *Ageratum conyzoides* Linn. (*Hulan-tala*, Sinhalese, and *Pum-pullu*, Tamil) which forms the subject of this paper was first observed by the junior author on an estate in the Kurunegala District of Ceylon, about two years ago. Diseased specimens were then few, and confined to one part of the estate only. Now, on unweeded portions of that estate and waste-land about it, the disease is so common that it is difficult to find healthy specimens of this weed.

Photographs of a typical diseased specimen at the flowering stage and of a young diseased plant after transplanting to a six-inch pot are reproduced as Pl. I., fig. 1, and Pl. II., fig. 3, respectively. A photograph of a healthy plant is also shown in Pl. II., fig. 1, for comparison.

Ageratum conyzoides is a common weed of cultivated and waste-lands throughout Ceylon and of itself is of no economic importance. Nevertheless, any disease to which the weed is subject becomes of great economic importance if it can pass readily to a crop plant and thereby cause loss. During the course of these investigations there were indications that tobacco is susceptible to the same disease, and that if tobacco is to be protected this weed would have to be completely eradicated from tobacco areas, particularly when tobacco is off the ground. Otherwise, the weed remains a continuous source of infection for successive crops of tobacco.

SYMPTOMS OF THE DISEASE

Viewed from the upper surface the veins of the upper leaves appear as yellow lines. The lines are actually broader than the veins themselves, as the yellow colour spreads slightly into the adjoining green tissues. This gives the diseased leaf a characteristic appearance ; numerous green islands are surrounded by yellow lines which coincide with the veins. We have used the term "yellow vein-banding" to describe this condition. Yellow vein-banding is usually less marked towards the base of the leaf ; there, the bands are often narrower and not so yellow. The difference between the bands at the base and apex of diseased leaves is well shown in Pl. II., fig. 3.

The yellow vein-banding is not so marked on the undersurface of the leaves. The veins are yellow and appear to stand out more prominently than in healthy leaves. This is due not so much to a swelling or abnormal growth of the veins as to the interveinal areas being raised somewhat and becoming concave on the under surface.

In addition to the characteristic vein-banding described above, a few plants exhibited a curl of the leaves. The edges of the leaves were curled downwards and inwards towards the lower surface. This condition, but in tobacco, not *Ageratum*, is shown in Pl. III., fig. 2. The *Ageratum* plants never showed the curl symptom so markedly as is illustrated in that figure.

A few plants amongst those exhibiting the curl symptom showed a third symptom, *viz.*, a thickening of the veins on the undersurface of the leaf. These thickenings were about a millimetre in length and occurred scattered haphazard, but always on the smaller veins. The plants which exhibited this symptom of vein thickening showed it on all leaves with yellow vein-banding.

Those plants which carried healthy leaves at the base of the stems usually had diseased leaves on the branches arising in the axils of the apparently healthy leaves. In such cases, it is probable that the leaves formed before infection occurs remain apparently healthy and do not display any of the symptoms characteristic of the disease, whereas all leaves formed after infection, develop the symptoms, no matter whether the new leaves are formed on the main stem from the terminal bud or on branches from axillary buds subtended by apparently healthy leaves. Evidence in support of that probability is given later.

TRANSMISSION EXPERIMENTS

To Ageratum Conyzoides

A number of wild *Ageratum* plants of the low-country, white-flowered variety, both healthy and diseased, were planted in six-inch pots and brought into the laboratory of the Tea Research Institute at St. Coombs.* The healthy and diseased plants were collected from different localities and were placed in separate rooms to avoid accidental infection. Twelve healthy plants were kept as controls, the remainder being used for experiments. No disease symptoms developed in any of these twelve control plants during the course of the experiments; so, no further mention will be made of them.

(*a*) *Mechanical Transmission.*—Juice extracted from diseased Ageratum leaves was rubbed lightly on to the 4 uppermost leaves of each of 12 healthy *Ageratum* plants. Half of each leaf-blade was inoculated in this manner; six of the plants had the juice

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Talawakele : elevation 4,500 feet.

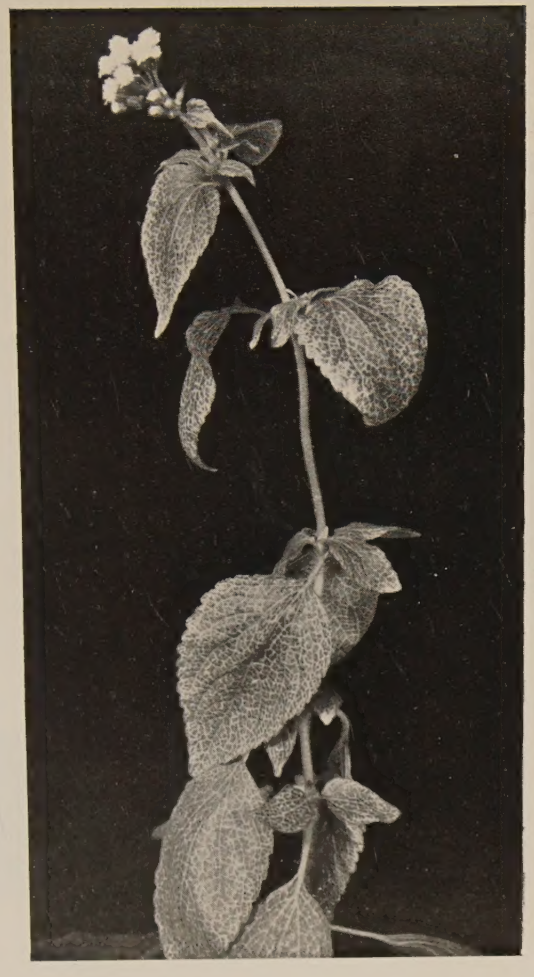

Fig. 1.—Diseased *Ageratum conyzoides* plant at flowering stage showing yellow vein banding.

Fig. 2.—Diseased scion grafted to healthy stock (*Ageratum*). Note the diseased leaves of the axillary branches of the stock.

rubbed on the upper surface of the leaves and the other six on their lower surfaces. Two months later, all the inoculated plants had produced a considerable amount of new growth and had reached the flowering stage, but in none had any symptoms of disease developed.

(*b*) *White Fly Inoculation.*—Eight healthy *Ageratum* plants were used in this experiment. Two healthy plants were placed in each of 4 insect cages, together with a diseased plant and a number of white flies collected from tomato plants. After five days, during which time the flies fed readily on both healthy and diseased plants, the flies were removed. None of the healthy plants later developed any symptom of disease.

(*c*) *Aphid Inoculation.*—An unidentified species of aphid, cream in colour, was collected from healthy *Ageratum* plants growing on St. Coombs, and a large number of these insects were transferred to diseased plants where they fed readily. After four days on the diseased plants the aphids were moved to the young expanding leaves of seven healthy plants, where they were allowed to feed for another four days before being removed.

All the leaves on which the aphids had fed became crinkled and curled, but the leaves which developed later on six of the healthy plants were normal. This crinkle may therefore be attributed solely to injuries caused directly by the aphids when feeding.

One of the inoculated plants, however, developed the characteristic yellow vein-banding symptom of this disease three weeks later. The symptom first appeared on the young leaves on which the aphids had fed, as a slight yellowing of the veins. All leaves produced later, not only on the main stem but also on all lateral shoots, showed vein-banding markedly. Those leaves which were fully grown at the time of inoculation remained green and apparently normal throughout the experiment. There was no evidence of transmission to any of the remaining six plants.

(*d*) *Grafts.*—Attempts were also made to transmit the disease by grafting. Five healthy and five diseased *Ageratum conyzoides* plants growing in pots and of approximately the same size were chosen. The upper three inches were cut from each main stem and used as scions. The diseased scions were grafted to the main stems of the healthy plants, and healthy scions to the diseased plants. The common cleft graft method was used, with raffia to bind the graft in position. The grafted plants were covered with bell jars, to maintain humid conditions for twelve days, the bell jars being lifted for a short time daily, for aeration. Good fusions between stocks and scions were made, as no wilting took place on removal of the bell jars after that period.

All five plants carrying *diseased scions*, sixteen days from the making of the graft, showed slight yellowing of the veins in the youngest expanding leaves of the shoots growing in the axils of the uppermost leaves of the healthy stock. On the nineteenth day, four of the five grafts showed definite yellow vein-banding symptoms in those leaves noted on the sixteenth day, and early symptoms were visible on the expanding leaves of the shoots in the axils of the second and third pairs of leaves below the union. The remaining graft, in which growth was rather slow, took longer to show the vein-banding symptom markedly. At the end of the experiment, two months after the grafts were made, all new growths from the healthy stocks were badly diseased.

Grafting appeared to aggravate the symptoms in the diseased scions, as later growth became stunted and the diseased leaves became curled and more markedly banded. No new growth was produced from the axillary buds of the diseased scions.

Pl. I., fig. 2, is a photograph of a graft of this series taken twenty-three days after the graft was made. The position of the union between healthy and diseased tissues is marked by an arrow. It will be seen from the photograph that the disease has passed to the previously healthy stock and that the symptoms are exhibited by the young leaves. Leaves which were fully grown before the graft was made remained green.

Although satisfactory fusion was obtained between diseased stocks and *healthy scions*, no symptom of disease was observed in the scions of any of the five plants grafted in this way, even after three months. The scions grew normally and the new leaves remained apparently healthy. The stock remained diseased, and all new leaves exhibited the vein-banding symptom. Observations ceased after the plants reached the flowering stage.

These results are in marked contrast with those obtained when healthy stocks and diseased scions were used. In the latter case, the virus—these experiments indicate that the disease is caused by a virus—moved readily downwards into the stock ; whereas the reverse movement is either very slow or non-existent.

To Tobacco

A few diseased *Ageratum* plants after potting, happened to be left in an open shed for a few days alongside some tobacco seedlings also growing in pots. Some time later, it was noticed that two of the tobacco seedlings were exhibiting symptoms of yellow vein-banding, exactly similar to that shown by the diseased *Ageratum* plants. The tobacco plants exhibited the symptoms only on the youngest leaves, the older leaves being of the normal green colour. This fact suggested a recent, and not a seed, infection. The tobacco seed was Harrison's Special,

supplied by the Department of Agriculture, and plants grown from the same sample of seed previously had all been healthy. There was therefore no grounds whatever for suspecting that the disease was in the seed originally.

The only insects which could be found on the diseased tobacco plants were a few white flies. It was decided therefore to attempt to transfer the disease from *Ageratum* to tobacco by means of white flies.

(*a*) *White Fly Inoculation.*—A diseased *Ageratum* plant was placed in each of two insect cages and white flies collected from tomato plants growing some distance away were introduced into the cages. The flies quickly settled down to feed on the *Ageratum* leaves. The following day, three young healthy tobacco plants (Harrison's Special) were put into one cage and two into the other. The white flies were then disturbed ; many then settled on the tobacco plants and began to feed. After the healthy plants had remained in the cages for four days all the plants were sprayed with nicotine sulphate and soap to kill off the flies. All plants, including the controls, were later examined daily to ensure their freedom from white flies or other insects.

The three tobacco plants which were enclosed in one cage were numbered 1, 2 and 3 ; the remaining two from the other cage were numbered 4 and 5. In addition, seventeen healthy tobacco plants from the same batch of seedlings were kept as controls. Plants 1, 2, and 4, and two of the controls later developed disease symptoms but these symptoms were not identical in all cases.

Plant No. 1 at the beginning of the experiment had five leaves and an expanding bud. Seven weeks later it had thirteen leaves of which the 8th, 9th and 10th showed symptoms of yellow vein-banding on half the leaf blades, the symptom on the 10th leaf being most marked. Viewed by transmitted light the yellowing of the veins, particularly the smaller veins, appeared equal on both sides of the leaf. The youngest leaves, Nos. 11–13, were not full grown and appeared normal. Seven weeks later, *i.e.*, fourteen weeks from the beginning of the experiment, the plant had twenty-two leaves. From the 8th to the 12th leaf vein-banding occurred on half the leaf blade only, but the symptom was more intensified than after the seventh week. Leaves above the 12th showed the symptom over the whole leaf blade, except the youngest which appeared normal. Expanding leaves did not show any symptom as a rule for three or four weeks after emergence from the bud.

Plant No. 2 followed much the same course as No. 1. Yellow vein-banding was the dominant feature and in this case, the symptom occurred over the whole leaf blades of the 8th and later formed leaves. In no leaf was the banding restricted to

half a leaf. The young leaves, newly expanding from the bud, tended to curl towards the lower surface but as they became older this tendency disappeared and the leaves became normal in shape except for a slightly wavy margin. Vein-banding, as shown in Pl. III., fig. 3 was the most notable symptom as it was in plant No. 1.

Plant No. 4, which was inoculated in the second cage, displayed somewhat different symptoms. Seven weeks after inoculation this plant had eleven leaves. The 9th counting from the base exhibited yellow vein-banding slightly over the whole leaf-blade, and the 10th showed it near the leaf tip only. Leaves 10 and 11 were curled, the edges tending to curve downwards and inwards towards the lower surface. Two weeks later, leaves 9 and 10 still showed vein-banding slightly, but some of the smaller veins on the under surface had begun to form dark green thickenings. The leaf edges were more markedly curled. Leaves 11, 12 and 13 were curled but showed no vein-banding. A large number of the veins on the under surface were thickened and a few bore leafy outgrowths or enations, both frill-shaped and cup-shaped, such as are illustrated in Pl. II., fig. 2. Leaf No. 14 was about 1 inch long, crinkled and curled but no vein thickenings or enations were present. The characteristic curl of the young leaf is shown in Pl. III., fig. 2, which should be compared with Pl. III., fig. 1, which is of a normally healthy apex of a tobacco shoot. Twelve weeks after inoculation, the plant had 22 leaves. All traces of vein-banding had disappeared from leaves 9 and 10, and no other leaves exhibited it. Instead, all the leaves from the 9th upwards were crinkled and markedly arched, the upper surface being convex, and the veins on the under surface were thickened and often produced enations. Enations remained small, the largest being about 7 mm. wide. Vein thickening was more common than enations. This plant became stunted in growth.

Of the seventeen control plants one developed the yellow vein-banding symptom markedly and at the same time exhibited leaf curl. Pl. III., fig. 2, is a photograph of this plant. Another developed leaf curl only without any vein-banding. The remaining plants were healthy and without any disease symptom when observations ceased as the plants entered the flowering stage.

DISCUSSION

The above experiments indicate that the disease (or diseases) of *Ageratum conyzoides* here described is probably caused by one or more viruses which are transferable to tobacco by white flies. From the symptoms on *Ageratum* and on tobacco it seems probable that at least two viruses are concerned ; one may cause the vein-banding symptom and the other, the leaf-curl with vein thickenings or enations.

Fig. 1 (top).—Apex of healthy tobacco shoot.
Fig. 2 (bottom).—Apex of diseased tobacco shoot. Note the leaf curl.

Fig. 3.—Tobacco leaf showing yellow vein banding.

The writers make no claim that the experiments here described are in any way critical. Such experiments are impossible in the absence of an insect proof plant house, and incidentally, the writers have not the time for such experiments as their interests lie mainly with the diseases of the tea bush. Their experiments, however, indicate the probability that the weed *Ageratum*, harbouring one or more viruses, is liable to cause trouble, if it has not already occurred, in the tobacco gardens of Ceylon. For this reason it seemed advisable to publish these observations in full.

Thung (8) in 1934 reported that *Ageratum conyzoides* harboured the virus of the tobacco leaf-curl disease in the Dutch East Indies and that this weed was one of the most important in carrying over the disease during the time when there was no tobacco in the fields. In 1936, Pruthi and Samuel (5) observed that *Ageratum conyzoides*, a very common weed at Pusa, India, suffered from a leaf-curl with symptoms resembling those of some types of diseased tobacco. Their experiments demonstrated that *A. conyzoides* is an alternate host of tobacco leaf-curl virus and that white fly can transmit the disease from this host to tobacco very easily.

Leaf-curl of tobacco was first recorded in Ceylon by Petch (3) in 1907, when the cause of the disease was unknown. His description of the curled leaves and the swellings of the veins leave no doubt that he was describing the disease commonly known as " leaf-curl ".

Leaf-curl occurs in Africa wherever tobacco is grown, and it is the most serious disease with which the tobacco grower must contend (6). It is also a disease of considerable importance in the Dutch East Indies (7) and India (2).

Storey (6) has described the effect of the disease in the following terms :—

" The leaf-curl virus is somewhat exceptional in producing normally no chlorosis, either general or in a mosaic pattern. Its characteristic effect is to induce hyperplastic growth in the form of enations upon the lower surface of the leaves. These enations are located along the smaller veins ; in them chlorophyll is strongly developed giving them the same dark green colour as the upper surface of the leaf itself. Normally the enations amount to no more than a thickening of parts of the leaf-veins, irregularly distributed, but at times they may grow out into frills or cups of considerable size.

" The enations are usually accompanied by uneven growth of the main veins and leaf-lamina, so that the leaves are fantastically distorted, crinkled and twisted. The plant is generally stunted, and the growth of the flowering stems in particular is reduced."

From the foregoing it is evident that the inoculated tobacco plant No. 4 had acquired the leaf-curl disease, which in all probability had been transferred from *Ageratum* to the tobacco. The fact that some *Ageratum* plants exhibited a mild leaf curl together with a thickening of the small veins on the under surface of the leaves clearly indicates that at least some of the *Ageratum* plants carried the tobacco leaf-curl virus. This observation is in accord with those of Thung (8) and Pruthi and Samuel (5) who have shown that *A. conyzoides* is a carrier of tobacco leaf-curl virus in the Dutch East Indies and India respectively.

The most pronounced symptom of the diseased wild *Ageratum* plants and of the inoculated tobacco plant No. 1 was the presence of yellow lines superimposed on the veins, here termed yellow vein-banding, and not a leaf-curl with thickened veins. The question which arises is " Is the yellow vein-banding symptom the result of infection by the leaf-curl virus or is it indicative of infection by yet another virus ? "

All descriptions of the leaf-curl disease of tobacco indicate considerable variation of the symptoms. Thung (7) differentiated three types of leaf-curl (kroepoek) of tobacco, two of which are characterized by the presence of enations, whereas the third, termed " transparent kroepoek " is distinguished by the curling of the leaves towards the ventral side and the clearing of the veins, enations being absent. Pal and Tandon (2) differentiated five types of leaf curl designated A, B, C, D, and X, two of which, C and D, are characterized by vein thickenings and enations being absent. Pruthi and Samuel (5) as a result of their experiments in transmission of the virus between tobacco and *Ageratum* concluded that *A. conyzoides* is an important alternative host of tobacco leaf-curl virus D. Amongst the symptoms of leaf-curl virus D are :—" Foliage colour normal green in early stages, tending to become yellowish green with advancing maturity . . . . . Vein clearing usually persistent in younger leaves but not so distinct as that in C, and moreover it does not extend to the smallest vein. " (2).

The writers are of the opinion that the symptom they have described as yellow vein-banding is not the same as that described by Pal and Tandon as vein clearing or by Thung as transparency. The illustrations of the diseased leaves of *Ageratum* published by Pruthi and Samuel (5) do not show yellow lines along the veins such as are evident in Pl. I., fig. 1, and Pl. II., fig. 3, of the Ceylon plants.

In Africa the early symptoms of leaf-curl disease of tobacco " often take the form of a clearing of the veins of a young leaf. Usually this effect is transitory, but rarely the pale network, visible from the upper surfaces, may persist " (6). The " pale

network visible from the upper surface " of Storey's description more nearly approximates our " yellow vein-banding " but that character in the specimens here described was common, not rare.

Thung (7) had attributed the transparent vein or pale network symptom to a virus distinct from that causing enations and his view is supported by Kerling (1). Pal and Tandon (2) consider that their leaf-curl types A to D are due to four distinct viruses and their type X as due to a mixture of two or more viruses in different combinations. Storey (6) however ascribes the symptom differences to climatic and soil differences and possibly to differences in the virulence of virus strains. The different symptoms noted in the inoculated tobacco plants 1 and 4 can hardly be ascribed to soil or climatic differences, though the possibility of a difference in virulence of the virus strains remains. So long as the differentiation of viruses is based on symptomatology in the absence of definite knowledge of the properties of the viruses concerned, such problems as this will recur.

One other point remains. Tobacco leaf-curl virus is usually transmitted by white flies as in the tobacco infections described here. The apparent transmission of the *Ageratum* virus to another *Ageratum* plant by aphids suggests the possibility that aphids as well as white flies also may transmit this yellow vein-banding virus. The experiment can, however, only be regarded as an indication of a possibility and nothing more.

The writers are of the opinion that the yellow vein-banding disease of *Ageratum conyzoides* here described is caused by a virus or strain of virus belonging to the tobacco leaf-curl group. It is possibly more nearly allied to the virus or strain which causes transparent veins than to the one which causes vein thickenings and enations. It also seems probable from the course of the disease in the inoculated tobacco plant No. 2 that the true leaf-curl virus may cause the yellow vein-banding symptom to be masked.

CONTROL

The removal and destruction of diseased plants on sight is probably one of the most practical ways of restricting the spread of such virus diseases as leaf-curl of tobacco. It is not sufficient merely to rogue the crop plant and supply with healthy plants, if weeds in the vicinity are harbouring the virus. Such weeds must be eradicated especially when the crop plant is off the ground. Thung (8) claims that control of tobacco leaf-curl can be secured by the timely removal of all sources of infection, including the weed *Ageratum conyzoides*, over a radius of some 50 metres round the tobacco growing villages.

SUMMARY

A disease of *Ageratum conyzoides* is described. The principal symptom is a yellow vein-banding.

The disease was successfully transmitted to healthy *Ageratum* plants by grafting and to tobacco plants by white flies.

The disease is caused by a virus allied to the virus or viruses which cause tobacco leaf-curl.

The eradication of the weed from tobacco areas is advocated.

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CULTURAL EXPERIMENTS WITH TURMERIC (*CUCURMA DOMESTICA* VAL.)

I. THE INFLUENCE OF MULCHING AND OF THE SIZE OF SEED ON THE YIELD OF SOME VARIETIES OF TURMERIC

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THE cultivation of turmeric in Ceylon has extended during recent years and, with the guaranteed price which is now laid down under the Agricultural Products (Regulation) Ordinance, its popularity has increased and is likely to increase further. With the increase in area under the crop has come the realization that our knowledge of methods of cultivation is limited. The note now published contains the results of the first stage of investigations that aim at supplying the gaps in our knowledge of cultural methods.

The application of straw mulches is a routine cultural practice in most turmeric-growing areas. The benefits claimed for the practice include the addition to the soil of quantities of organic matter and potash, the checking of weed growth and the conservation of soil moisture. The last mentioned factor is probably of little importance in the conditions of heavy precipitation under which turmeric is normally grown in this country. An examination of the effect of rice straw mulches was included in the present study.

The cost of seed rhizomes is an item of some magnitude in turmeric growing, and the effect of reduced seed rates on yield is, accordingly, of interest. The effect of bisecting the seed rhizomes longitudinally was one of the factors investigated in the experiment reported in this paper.

A trial of three varieties of turmeric, viz., a local variety and two introduced Indian varieties, Poona and Guntur, was superimposed on the cultural studies.

THE DESIGN OF THE EXPERIMENT

The following treatments were included in a 3 × 2 × 2 factorial design :—

Three varieties :	V_0 — local
	V_1 — Poona
	V_2 — Guntur
Two sizes of seed :	P_0 — Whole rhizomes
	P_1 — Rhizomes bisected longitudinally
Two mulching treatments :	M_0 — Unmulched
	M_1 — Mulched with rice straw

There were three replications in six blocks of six plots and the interactions PM and VPM were partially confounded with block differences in each replication. For a detailed exposition of the design, reference may be made to Yates (1937).

The plants were spaced 1 × 1 ft. in 1/681 acre plots. There were no guard rows between plots, but in the harvest a single border row was rejected round each block.

EXPERIMENTAL MATERIAL AND METHODS

Strictly comparable planting material of the three varieties included in the trial could not be procured. The available material consisted of mother setts of the local and Guntur varieties, and " fingers " of the variety Poona. The Indian material had been imported direct.

The experiment was set down at the Experiment Station, Nugawela, in the 1940–41 season. The soil of the experimental area was a light loam of average fertility. The land received a dressing of compost of 25 tons per acre on the eve of planting. The rhizomes were planted on May 7, 1940. A mulch of 20 lb. per plot of rice straw (6 tons per acre) was applied to the M_1 plots on the date of planting. The mulch was subjected to continual disturbance by the strong winds that prevailed, and had to be weighed down by strips of wood. The M_0 plots, which were not mulched with straw, received a light soil mulch. All plots received two weedings. Precipitation during the experimental period was abnormally heavy.

The dates of sprouting of the local, Poona and Guntur varieties were May 29, May 31, and June 4 respectively. The variety Guntur, although a late sprouter, showed subsequently much more vigorous vegetative growth than either of the other two varieties. The plots mulched with straw exhibited earlier shoot development. In the variety Poona, reduction in size of seed depressed the vegetative vigour of the plants ; plants grown from whole " fingers " were appreciably taller.

Except for slight damage by the pyralid caterpillar, *Dichocrocis punctiferalis* Guen., pests and diseases were refreshingly scarce. The caterpillar bores into stems and shoots of turmeric. The extraction of the borer from invaded plants by means of a thin wire effectively checked the infestation. Susceptibility to borer attack appeared to be positively correlated with plant vigour. This correlation probably accounted for the higher incidence of stem borer in the variety Guntur.

Some of the plants flowered on October 2. The local variety had begun yellowing on December 12. The other two varieties had yellowed by January 13, 1941.

The crop was lifted on January 30.

RESULTS

The weights of rhizomes produced by plots subjected to the various treatments are presented in Table 1. The analysis of variance of these data is given in Table 2. The variance ratio for total treatments attains significance at the 0·1 per cent. point. The variance ratios for varieties and mulchings are significant at the 0·1 per cent. point, and that for size of seed at the 5 per cent. point. None of the interactions exhibit significance.

The examination of individual variety totals with the aid of their standard error reveals the significant superiority of the variety Guntur.

The large and significant increase in yield effected in this experiment by mulching can probably be traced to the manurial value of rice straw.

The reduction in yield accompanying reduction in seed size was particularly marked in the instance of " fingers " of the variety Poona. The economic implications of these depressed yields are, however, not quite clear.

SUMMARY

The results of an experiment set down in *maha*, 1940–41, at the Experiment Station, Nugawela, for the purpose of investigating the effect of mulching and of the size of seed on the yield of some varieties of turmeric, are reported.

The variety Guntur yielded a significantly greater weight of uncured rhizomes than either the variety Poona or the local variety.

Mulching the crop with rice straw at the rate of 6 tons per acre produced a large and significant increase in yield.

Reduction in the size of seed depressed yields considerably. Longitudinal bisection of mother setts in the local and Guntur varieties, and of " fingers " in the variety Poona resulted in a significant reduction in yield.

ACKNOWLEDGEMENT

We are indebted to Mr. E. C. Wirasinha, Agricultural Instructor, Katugastota, for his careful supervision of the field operations.

REFERENCE

Yates, F., 1937 .. The design and analysis of factorial experiments. *Imperial Bureau of Soil Science, Tech. Comm. No. 35.*

TABLE 1.—Yields of Uncured Rhizomes in Pounds

		Varieties			Total
		V_0	V_1	V_2	
Mulchings	M_0	138·4	128·0	238·5	504·9
	M_1	232·6	183·9	323·1	739·6
	Total	371·0	311·9	561·6	1244·5

		Varieties			Total
		V_0	V_1	V_2	6
Sizes of Seed	P_0	193·4	200·3	293·8	687·5
	P_1	177·6	111·6	267·8	557·0
	Total	371·0	311·9	561·6	1244·5

		Sizes of Seed		
		P_0	P_1	Total
Mulchings	M_0	298·6	206·3	504·9
	M_1	388·9	350·7	739·6
	Total	687·5	557·0	1244·5

TABLE 2.—Analysis of Variance of Yields of Uncured Rhizomes

	DF	SS	MS
Blocks	5	1959·1	391·8
Treatments	11	5277·4	479·8*
V	2	2838·1	1419·0*
P	1	473·1	473·1†
PV	2	259·7	129·8
M	1	1530·1	1530·1*
MV	2	66·2	33·1
PM	1	9·8	9·8‡
PMV	2	100·4	50·2‡
Error	19	1198·8	63·1
Total	35	8435·3	

* Significant at the 0·1 per cent. point.
† Significant at the 5 per cent. point.
‡ Partially confounded with blocks.

RECENTLY INTRODUCED FOOD CROPS AT THE EXPERIMENT STATION, PERADENIYA
III.—COWPEA: BOMBAY VARIETY

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COWPEA is an important leguminous crop which is increasing in popularity in the tropics. It is grown principally for four distinct purposes. In India this is chiefly cultivated as a seed crop for the use of grain as an important pulse food. The pulse is used in a variety of ways. Cowpea seed has a high food value and contains 24·56 per cent. protein and 3·23 per cent. mineral matter which clearly indicates that it very favourably compares as food in respect of these two nutrients with other pulses in common use such as Bengal gram, green gram, black gram, dolichos lablab beans, dhal and lentils. Studies conducted by the Bureau of Home Economics of the Department of Agriculture, U. S. A., indicate that, in food value, digestibility and flavour, cowpea ranks well with beans and peas as a staple article of diet. In Ceylon, however, the cultivation of this crop for seed purposes is practically unknown and cowpea grain is not used as a pulse food in the diet of the people. The next important use to which this crop is put is as a vegetable. The cultivation of this crop in Ceylon is chiefly devoted to the production of tender green pods to be sold as a vegetable. The vegetable is appreciated all over the country and there is an extensive demand for it throughout the year. To meet this demand the crop is grown under a wide range of conditions and suitable varieties have been developed. The great point in favour of the cultivation of this crop for vegetable purposes is that it can be grown quite satisfactorily under wet zone conditions on well-drained land. The crop is also grown in India for green manure

and fodder purposes. In this case the choice falls upon those varieties which have a spreading habit of growth and which produce luxuriant vegetative growth.

The range of pulse grains used in the normal diet of this country is very limited and is confined chiefly to green gram. Cowpea seed is almost as rich as green gram in respect of protein and mineral matter and is not difficult to digest. As such the use of cowpea seed will not only add to the variety in the diet but will also help in the development of a better-balanced diet. Under such circumstances an attempt was made for the introduction of a suitable grain variety possessing certain desirable features such as high yielding power of seed, vigorous and erect habit of growth, the ease with which it can be cultivated and early maturity so that the crop can be conveniently fitted into any scheme of rotational cropping.

With these considerations in view, the seed of the variety which is now popularly known as Bombay cowpea was obtained from India. It was first grown at the Experiment Station, Peradeniya, during the south-west monsoon season of 1938. The crop yielded without any manurial treatment 320 lb. seed per acre under adverse climatic conditions. This small scale trial appeared quite promising. Since then it has been grown almost every season at the Experiment Station, Peradeniya. The wet zone conditions are really not favourable to the grain variety of cowpea and as such the yields at the Experiment Station, Peradeniya, are not up to the expected standard. It has now also been introduced at some of the departmental stations in the dry zone. Dry zone conditions are definitely more favourable for a grain variety of this crop, and the crop has shown excellent performance under the favourable conditions of the dry zone. This variety has now been acclimatized under the local conditions. The characteristic features of this variety are: erect and vigorous habit of growth, short growing period, fairly uniform maturity which enables the crop to be harvested in one operation, the compact and well-filled medium-sized pods which do not burst open on maturity thus preventing the loss due to shattering of seed from a mature crop. The seed which is fairly heavy and attractive in appearance yields dhal of good quality on splitting and curing. Another point in favour of this variety is that in the dry zone it is almost free from the attack of aphides and agromyza fly to which the vegetable varieties are easily susceptible. It is quite hardy and able to resist drought better than the ordinary vegetable varieties and yields a distinctly better crop during the dry season than the other vegetable varieties grown at the Experiment Station, Peradeniya. This variety is ready for harvest under local conditions in 3 months after sowing.

Being a leguminous crop with considerable growth of bacterial nodules and with the shedding of substantial amount of leafy matter during the course of the growing period, the crop enriches the soil in respect of nitrogen and organic matter. Besides thus raising the standard of soil fertility, the cowpea crop also improves the physical condition of the land. As such it admirably fulfils the requirements of an excellent short period rotational crop under the dry zone conditions.

SOIL REQUIREMENTS

Cowpea will grow well on well-drained, moderately-light loam or medium loam soils. Being a leguminous crop, the presence of lime in the soil is essential. On rich soils a comparatively thick vegetative growth results and the yield of seed is low. For a seed crop soils of medium fertility are best suited.

CLIMATIC REQUIREMENTS

Cowpea requires a fairly warm growing season for its proper development. This particular variety is able to withstand drought better than the other locally grown vegetable varieties. For a seed crop continuous rain is not favourable during the period of flowering or of ripening of pods. The best results are obtained when growth takes place during a reasonably warm period with a fairly good distribution of rainfall and when bright weather prevails during and after flowering. Consideration of these climatic requirements clearly indicates that the dry zone is the most suitable place for this grain variety of cowpea. It will grow in the wet zone on a well-drained soil under fairly heavy rainfall, but in this case it will-distinctly run towards vegetative growth and the yield of seed will be comparatively small.

SUITABLE SEASON

In parts of the dry zone which receive about 20 inches or more rain during the south-west monsoon season this pulse crop can be grown during that season. It may be grown during the north-east monsoon season in parts where this monsoon is not so heavy and where a dry period is available in January and February for the pods to ripen. It can also be cultivated during the south-west monsoon season on certain types of paddy lands under the village tanks where the soil is light and well drained, during years when the available supply of water is not considered enough for the growing of the paddy crop.

METHOD OF CULTIVATION

The land should be ploughed to a depth of about six inches and then brought to a fairly fine state of tilth by subsequent

harrowing. Usually this crop is not manured but it responds to the application of three to five tons cattle manure or compost during the course of the preparatory tillage.

For the Bombay cowpea, the spacing of 18 inches between rows and 12 inches within the row has been found suitable under the local conditions. The crop can, therefore, be sown by a three-coultered drill if available or it can be sown by dibbling in rows previously marked to a spacing of 18 inches. Two to three seeds should be dibbled to a depth of about an inch in each hill 12 inches apart in the row. Cowpea seed maintains its germinating power for five to seven years and therefore there is no necessity to sow unduly thick with a view to securing a good stand. The seed rate per acre under these conditions of sowing as an entire crop usually ranges from 15 to 20 lb. This can be grown as a mixed crop with sorghum or gingelly and in that case the seed rate will be proportionately low.

The crop germinates on the fifth day. Thinning and filling up of vacancies if necessary should be attended to as soon as possible after about 12 days of sowing. Not more than two plants should be allowed to stand in each hill. With this variety only one intercultivation is possible and that should be done about three weeks after sowing. The crop then rapidly grows and almost covers the land.

The first crop of pods can be harvested in tender stage for the vegetable market. This adds to the profit from the crop. The seed crop is ready for harvest from three months after sowing. As the crop matures fairly evenly and as there is no possibility of loss of seed by shattering from the pods, one can wait till most of the crop is ready for harvest. It is a pleasant sight to see a field of cowpea of this variety almost covered with creamy-white pods just before harvesting. The crop is harvested in one operation by cutting the plants close to the land. These are then dried and threshed out either under the feet of bullocks or by beating with wooden flails. The seed can be cleaned by the usual winnowing. The broken straw obtained as a bye-product of threshing is a valuable foodstuff for all types of farm animals.

YIELDS

The yield of a normally good crop in India ranges from 500 to 1,000 lb. dry seed per acre. At the Experiment Station, Peradeniya, the crop has suffered from heavy rain on many occasions. Under such adverse climatic conditions, on a light type of soil and without any manuring the crop yielded 498 lb. dry seed per acre at the Experiment Station, Peradeniya,

during the south-west monsoon season of 1940. Yields approximating this figure have not so far been recorded for any other variety of cowpea grown at this station. The crop has however done distinctly better under the dry zone conditions for which it is intended. It is interesting to note that this variety of cowpea has yielded 18 bushels and 8 measures or 1,131 lb. dry seed per acre at the Experiment Station, Anuradhapura, on ordinary light soil, under ordinary conditions of cultivation and attention and without any kind of manuring.

METHOD OF USE AS FOOD

It can be used like green gram in the form of whole grain after cooking and flavouring with the usual currystuffs. It can also be used in a variety of ways like dhal after splitting the seed into halves and removing the seed coats.

WEEDING IN THE UP-COUNTRY TIMBER AND FUEL-PLANTATIONS

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THE earliest Timber and Fuel-plantations in the Up-country Division appear to have been initiated sometime between 1890 and 1900; but systematic planting dates from about 1916 and has continued almost in unbroken sequence up to the present. The total area under plantation as at the end of September, 1940, is 7,536 acres of which 2,028 acres are of *patana* or grassland afforestation and the rest reforestation of montane forest. The latter has involved the conversion to selected exotic timber and fuel species of part of the natural wet evergreen sub-tropical montane forest located in the highest peneplane of the central mountain massif of the Island. Afforestation has for the greater part concerned the dry *patana* grassland of the Province of Uva and very little of the black wet *patana* of the higher reaches of the Central Province.

The principal centres of reforestation have been :—Kandapola, Ohiya, Conical Hill, Pattipola–Ambawela, and more recently Mahacoodagala. The rainfall in this tract results from either of the two monsoons or both supplemented by not infrequent intermonsoonal local thunderstorms. The first two and the last of the centres mentioned are predominantly north-east monsoon areas whilst the remaining centres are considerably wetter and experience rains from both monsoons. The afforestation centres—Errabedde and Kinigama—are north-east monsoon areas slightly drier than the other north-eastern monsoon areas mentioned and characterized by more marked and protracted annual periods of drought during which scorching dry winds are experienced.

"*Clean Weeding*", an operation that consists of the scraping or even cutting off about 1 to 2 in. of the surface soil by mammoty in the eradication of ground—chiefly herbaceous—weeds and bracken (*Pteridium acquilina*), has been practised for varying periods of years at the commencement of each new plantation and is still in vogue except on the steepest slopes.

This practice of wholesale clean-weeding appears to be a custom or habit borrowed from the tradition of annual crop farming in England by the pioneering coffee planters and later followed by their successors, the tea and rubber planters. The example of these industrial agriculturists has in turn been copied in the tending of our own Timber and Fuel-plantations in the Up-country Division.

Up to recent times, absolute tidiness on the plantation floor until the tree crop was adjudged large enough to look after itself—and this was often given an over-generous margin of time—was nearly as much the fetish as it has been with the planters. "Permanent" weeding contracts, automatically renewed every 3 months, used to run through each financial year, and weeding recommenced at the beginning in each annual plantation area or "coupe" as soon as it was completed at the other end. Good work was judged by the lack of anything green but the tree crop introduced; and the plantations, except for the actual crop tended and the absence of soil cultivation or manuring, carried much the same appearance as tea estates managed according to the accepted practices of those days.

It is not possible in the absence of detailed figures, which have not been kept, to assess accurately costs per acre for each successive year of weeding and so to arrive at the average total formation expenditure per acre on weeding. From a careful study of the Annual Estimates for the 10-year period 1925–26 to 1934–35 inclusively there does not appear to have been any difference in annual weeding costs per acre between forest and *patana* plantations and estimates have been on the same basic rates. As might be guessed costs have been heavier in earlier times becoming less later on. The period of weeding has generally been 4 to 5 years and much longer in earlier plantations going up to 8 years in some cases owing to failure of the species first tried. The following table gives a fair idea of the average costs per acre for each year of weeding :—

	Range of Costs	Approx. Av. costs per acre Rs.
First Year—		
Clean weeding ..	Rs. 10 to Rs. 20 ..	15
Second Year—		
Clean weeding ..	Rs. 5 to Rs. 15 ..	10
Third Year—		
Clean weeding ..	Rs. 5 to Rs. 15 ..	10
Fourth Year—		
Clean, strip or circle weeding	Rs. 2 to Rs. 5 ..	5
Fifth Year—		
Mostly circle weeding ..	Cents 75 to Rs. 5 ..	2

The average total costs of weeding previously incurred may therefore be reasonably, though still conservatively, assessed at a round sum of *Rs. 40 per acre.*

In 1934–35 weeding estimates were drastically cut down all round and weeding reduced to the minimum thought possible. In view of the poor results with the exotic species then used in *patana* planting, it was decided in future to use *Eucalyptus robusta* 75 per cent. made up with 25 per cent. of selected Timber Eucalypts—(*Eucalyptus citriodora*, *E. maculata*, *E. microcorys*, &c.) for general grassland afforestation. At the same time it was decided to initiate investigations with a view to determining the minimum intensity and frequency of weeding consistent with the establishment of plantations of satisfactory quality in reasonable time.

The following five different treatments covering a wide range of intensity and frequency of weeding were decided on :—

Treatment A.—Clean weed throughout. 4, 3, and 2 weedings in the 1st, 2nd, and third year of plantation respectively.

Treatment B.—Clean weed 3 times in the 1st year. Strip weed contour-wise 3 times in the 2nd year. Patch weed twice in the 3rd year.

Treatment C.—Strip weed contour-wise 3 times in the 1st year. Patch weed 3 times in the 2nd year. Patch weed once in the 3rd year.

Treatment D.—Patch weed 3 times in the 1st year. Patch weed twice in the 2nd year. Patch weed once in the third year.

Treatment E.—Clean weed as and when found desirable in the 1st year. Strip weed as and when found desirable in the 2nd year. Strip or patch weed as found desirable in the 3rd year.

Six sets of considerably large experimental plots were laid down accordingly—4 sets in reforestation and 2 sets in afforestation centres—all in November, 1935, excepting the sets of plots at Pattipola-Ambawela which were planted in July of the same year. The plots were made as large as possible from the total area of cleared land available for planting at each place so that reasonably reliable costings may be kept.

The prescriptions laid down were generally closely followed in practice except that, in the case of treatment E, it was left to the Divisional Forest Officer, Up-country Division, to adopt the

kind and frequency of weeding he considered necessary for each year. Consequently the actual treatments the E plots were subjected to, varied at different centres and were as follows :—

I.—Kandapola—Clean weeded once each year for 3 years.

II.—Conical Hill—Clean weeded generally and strip weeded on steep slopes once in the 1st year. Clean weeded once each year for the next two years.

III.—Pattipola-Ambawela—Clean weeded once each year for 3 years.

IV.—Ohiya—Clean weeded twice in the 1st year. Strip weeded twice in the 2nd year.

V.—Kinigama—Patch weeded once each year for the 1st two years. Strip weeded twice in the 3rd year. Patch weeded once each year for the next two years.

VI.—Errabedde Strip weeded twice in the 1st year. Strip weeded 3 times in the 2nd year. Strip weeded once each year for the next two years.

It was intended that treatment should cease as soon as the majority of the plants reached the pre-determined *establishment heights* which were arbitrarily fixed at 10 ft. and 6 ft. respectively for the broad-leaved species and cypress. In practically all the reforestation plots and the more-intensely weeded of the afforestation plots, weeding was discontinued at the end of the *2nd year from planting.* The other less-intensely weeded plots were generally patch weeded two years more up to 1940.

Counts of survivals and measurements were taken from 3 to 8 indicator plots arranged to give as representative a sample as possible of each of the larger unit experimental plots. Mean heights were taken by direct measurement of 200 sample trees of cypress or *Eucalyptus robusta*, and generally when available 100 of each of the other timber species—*Acacia melanoxylon* and *Eucalyptus maculata*—taken *at random* evenly spread out in each of the chosen indicator plots within each major experimental plot. In the smaller experimental plots counts and measurements were confined to the inner plots leaving surrounds to offset marginal effects.

Rather than attempt to be concerned with all the species used in the plantations it was decided, in view of obvious practical difficulties any such attempt would entail, to be content with the examination of selected principal type species to judge of the results of the trials. For the reasons that they were the most uniform as regards growth and stocking and also formed 75 per cent. of the plantation mixtures used in reforestation and afforestation respectively, *Cupressus macrocarpa* and

Eucalyptus robusta are naturally to be regarded as the principal test species. As representative of the other timber species, *Acacia melanoxylon* was chosen in view of its having been the only species represented in all of the 20 forest-land plots and also as it was in greater number per plot than those of the other timber species used. Unfortunately, however, owing to damage occasioned by sambhur, after the 3rd year particularly, the species proved unsuitable for checking up final results, and, instead, *Eucalyptus maculata* had to be used as was done also for assessment of results in the case of the Patana Weeding Experimental Plots.

It would be best, before going on to discuss the results of the experiments, to review the factors most likely to influence the intensity and frequency of weeding required in any general case to give any satisfactory results :—

THE QUALITY AND INTENSITY OF THE INITIAL BURN

The more intense the fire and the more uniformly spread the burn-off of the brush-wood and "lop and top" on the site cleared for planting the less, obviously, would be the subsequent weed growth. Up to a point a good burn will also promote early growth apart from bringing about a reduction of the incidence of the weeds and so reduce subsequent spread of the weeds by the increased cover given by the tree crop. These effects will naturally be less in grassland afforestation than in forest land reforestation. Of the latter type of plots those of Kandapola and Pattipola-Ambawela had the best burns of the year. The Ohiya plots were next best, and in the Conical Hill plots the burn was poor and very patchy. The differences in the amount of weed and consequently costs of weeding at these different centres (*vide* Table II.) is in part a reflexion of the kind of burn each set of plots had received.

THE RAINFALL

Other things being equal the greater the amount of rainfall and the better distributed it is throughout the year, the greater would be the incidence and growth of the weeds. Thus, as is to be expected, weed growth is less at Kandapola and Ohiya and much worse at Conical Hill and at Pattipola. The resultant effects of different grades and types of weeding employed must also depend on the rainfall experienced during the period covered by the experiments. Table IV. gives the monthly average rainfall at each centre for the periods preceding first and final measurements respectively, together with the mean monthly rainfall averages of the localities concerned for comparison with the former. This mean monthly rainfall has, in the absence of figures over a sufficiently long period, been taken in each case from figures kept by adjoining estates—except for Ohiya

and Errabedde where adequate statistics from within the area of the plantations were available. For 3 of the former cases, however, average figures for the period of $3\frac{1}{2}$ years from statistics kept by the Department are given for comparison with those of the nearest local rain gauge station.

It will be observed that the rainfall over the experimental periods before first and final measurements have generally been heavier than average and agrees rather closely with the averages for the past $3\frac{1}{2}$ years taken from local Departmental readings at each centre. Rainfall averages for the period preceding first measurements have been approximately 8, 11 and 20 per cent. higher than normal for Ohiya, Pattipola-Ambawela, and Kinigama respectively. It cannot, therefore, be said that the experiments have been conducted over a period in which weather conditions were less favourable than normal to weed growth—thereby making less intensive and more curtailed weeding possible than would have been feasible under normal conditions.

SOIL

It is to be expected that weed growth is likely to be heavier in the richer and more fertile soils than in the poor soils. Fertility is not any intrinsic quality of what are recognized as good soils but merely an acquired character arising out of biological processes above and within the soil dependent mainly on the vegetation that has covered it. The removal of this covering vegetation and continued exposure of the soil by weeding inevitably leads to soil deterioration and such effects will naturally be most evident in soils that were poor to start with. It is unnecessary to go into the causes responsible for this loss of initial fertility. They are complex and manifold. Interference with the life processes of the soil faunal and floral population and consequent loss of soil structure rather than loss of soil nutrient through erosion are more likely to be responsible particularly in the early stages.

Soil profiles were examined in all the experimental plots taking generally 4 pits per plot one at the top, one at the bottom, and two on the mid slopes of each plot. The geological origin (Charnockite) and mineral nature of the soils appear to be the same in both the forest and the grassland areas. The soils in the reforestation plots are closely alike—a dark-grey, sandy loam overlying a deep yellow or reddish-brown, slightly micaceous, clayey loam mixed with ferrugineous and quartzose gravel in varying proportions. Granite and quartz stones and boulders are common, and as in the *patana* soils a hard, compact stratum of gravel frequently appears usually about $1\frac{1}{2}$ ft. to 2 ft. from the surface. The better soils of the *patana* as found for example in plots given to treatment A, B, and C at Errabedde

and A, B, and E at Kinigama are similar to the forest soils but are less humose and lighter in colour. The poorer soils of the *patana* appearing in knolls, hill-tops, and ridges are truncated degrades of this general soil type bringing the gravel and boulders nearer or right to the surface. This type of degraded soil is represented in plots given treatment E at Errabedde and C, D, and E_2, at Kinigama. On the whole the soils of the *patana* grassland plots are poorer than those of the forest plots.

As a general rule weed growth in the reforestation plantations is least in the year following clearing and burning and becomes progressively heavier in subsequent years, until the plantation crop begins to close over. In dry *patana* grassland impoverished by frequent grass fires, grazing and erosion, which later receives an added impetus by the clearing and burning of the surface vegetation preparatory to planting, the weed growth tends to be heaviest in the first year and becomes less in subsequent years and progressively weaker and scantier still the longer clean weeding is continued. If clean weeding is persisted in long enough, a naked, barren plantation floor is produced. The diminishing degree of the incidence of the weeds reflects the cumulative deterioration of the soil quality and when the last stage is reached conditions are hopeless and perhaps worse for the tree crop than those produced by the weeds. This has happened already in certain of our plantations on the *patana*, notably in the dismal 216 acres of 1926 at Kinigama.

Fortunately the species adopted for general afforestation with the initiation of these experiments are generally better suited to local conditions and the hazards of complete soil loss except on hill-crests, &c., where there is not much to lose any way are much reduced. The dangers of excessive weeding, particularly in the *patana* grassland plantations, are real and require to be kept in mind.

GRADIENTS OF SLOPE AND ELEVATION

It has already been mentioned that interference with the organic life processes of the soil and loss of structure are probably the first detrimental effects of soil exposure. The intensity of insolation in the rarified atmosphere of high elevations is likely to aggravate such effects.

On the degree of slope would depend the amount of interference with the surface soil and erosion consequent on weeding operations; hence the frequency and intensity of weeding conducive to the best results must vary in the inverse ratio to gradient. The forest plantations are all above 5,000 ft. and up to a little above 6,000 ft. in elevation. As may be surmised, gradients of slopes are generally steep to moderately steep.

The grassland plantations are all below 5,000 ft. in elevation ranging from about 3,800 ft. to 4,500 ft. Gradients of slopes involved here are generally less steep than in the higher elevation forest plantations. Owing, however, to (*a*) the nature of the soil, (*b*) the vegetational cover or lack of it, declivity is more conducive here to soil loss and deterioration.

It will be seen from Tables I. and II. that weeding in any of the forms followed in these experiments has not, as far as the forest land plantations are concerned, been required beyond a period of *2 years* from planting. It has happened, however, that weeding in the set of plots at Pattipola-Ambawela and in plot D of Conical Hill was continued to the 3rd year. In the former case the plot given to treatment A was twice clean weeded in the third year, those of treatments B, C, and D were patch weeded once and plot E received one clean weeding. The growth of the constituent species in plot E, the poorest plot of the set, was still better than that realized at any other centre in the same year. Weeding, therefore, was not strictly required though done. In plot D, Conical Hill, a single patch weeding was carried out in the 3rd year presumably more to improve appearance owing to rank growth of brambles than out of regard to the growth of the trees crops. This will be evident from a comparison (*vide* Table I.) of the mean heights of cypress and *Acacia melanoxylon* in this plot with those of plots C and E adjacent to it in which weeding ceased in the 2nd year.

In the case of the *patana* grassland plantations, weeding was very definitely unnecessary beyond the 2nd year from planting in respect of plots given to treatments A and B at both Kinigama and Errabedde. At the latter centre where soil conditions have been better this is equally true for treatment C (*vide* Table I.). Mean heights of *Eucalyptus robusta* varied from 12·5 ft. to 21·5 ft. and of *Eucalyptus maculata* from 13 ft. to 19·3 ft. at initial measurements.

As regards the other less intensive forms of weeding, treatment may safely have been discontinued by the end of the 4th year at the latest.

The average total formation costs per acre on weeding from details of expenditure kept by the territorial management staff, as given in Table II., are as follows :—

	Reforestation Plots.	Afforestation Plots.
	Rs. c.	Rs. c.
Treatment A	.. 10 34 per acre.	.. 14 65 per acre.
,, B	.. 9 44 ,,	.. 13 53 ,,
,, C	.. 9 0 ,,	.. 13 60 ,,
,, D	.. 7 62 ,,	.. 9 43 ,,
,, E	.. 7 75 ,,	.. 15 25 ,,

Strangely enough there has apparently been little difference as regards average costs of the first 3 forms of treatment, and that there should be less than the difference of a rupee between average costs per acre of treatment A as compared with treatment C is difficult to understand. It is clear, however, that the most expensive form of weeding has not been much more than ¼ to ⅓ the expenditure estimated for the period 1925 to 1935 (*vide* paragraph on average costs per acre). The costs per acre given in Table II. represent the total amounts expended up to the date of final measurement for the periods of weeding indicated.

For examination of the treatment effects as shown by survival percentages and mean height growths, it would suffice to take statistics collected in the 3rd and 5th years of treatments, the first being after weeding terminated in the reforestation plots and the more intensely-weeded of the afforestation plots and the final measurements when weeding was terminated in the rest of the plots. The full summaries of the statistical data are given in Tables I., II., and III.

REFORESTATION WEEDING TRIALS

Kandapola

At initial measurements, treatment plots B and E were significantly better than the continuously-weeded plot A–plot B as regards the growth of the cypress and *Eucalyptus maculata* and plot E in respect of that of *Acacia melanoxylon.* Plot D (patch weeded) was significantly worse than plot A in respect of the growth of all 3 test species. Plot C showed no significant difference from plot A as regards the growth of the cypress or *Eucalyptus maculata* but was just significantly worse than A in respect of *Acacia melanoxylon.* Survival percentages of all species were very satisfactory and, on the whole, of the same order for all 5 plots.

At final measurement (*vide* Table II.) a general levelling up of the first differences between the plots was to be noted. Plots B, C, and D were neither significantly better in respect of the growth of the cypress nor worse as regards the growth of the *Acacia melanoxylon* than plot A. Treatment E showed up best in respect of the growth of all species the mean heights of which were significantly better than that attained in other treatment plots—but its position appears to have favoured this particular plot.

Sambhur caused considerable damage as indicated by percentages of plants of *Acacia melanoxylon* browsed shown in Table II. The incidence of the damage in plots A, B, C, and D being about the same, no appreciable difference has probably been caused to their relative differences.

In September, 1940, there were no apparent differences favouring the less-weeded plots. If anything, such differences as were noticeable as regards growth and general conditions appeared slightly in favour of the least-weeded plots D and E. All plots were doing well and canopy was closed or fast closing up in all of them.

The results from the set of trials carried out at Kandapola indicate that *any* of the lower grades of weeding would to all practical purposes have been as acceptable as the district management practice of continued clean weeding.

Conical Hill

At first measurement, treatments B, C, D, and E were all significantly worse than treatment A in respect of the growth of both test species except in the case of treatment B where the lower mean height as compared with that of the same species in plot A carried no significance. Survival percentages of cypress and broad-leaved timber species were satisfactory and of about the same order for all plots except for broad-leaved timber species in plot E which was only 40·5 per cent. (*vide* Table I.).

At last measurement (*vide* Table II.), there has again been a general levelling up of differences, and treatment C was no longer significantly worse than treatment A in respect of the growth of either of the indicator species used.

Sambhur damage suffered by the *Acacia melanoxylon* precludes direct comparison of the mean heights attained by it in different plots but the incidence of the damage being the same for plots A, B, and C, the non-significance of the difference of the mean heights of this species in plots A and C can scarcely be treated as not confirming the more definite indication given by the cypress.

In September, 1940, plantations in plots A and D had closed up well. The stocking and condition of the standing plots B, C, and E were satisfactory though canopy had not closed up yet. The floor in plots C and E was covered with a heavy, mostly herbaceous, weed growth.

It would appear from the results here that a lower intensity and frequency of weeding than that followed in treatment A is feasible. In the end treatment C has proved no worse than treatment A.

Pattipola-Ambawela

At initial measurements, treatments B, C, D, and E were again all significantly worse than clean weeding throughout except that the differences of the mean heights of *Acacia melanoxylon*

and *Eucalyptus maculata* in plots A and B were not significant Survival percentages of all species were satisfactory and of about the same order for all the plots—*vide* Table I.

Final measurements show that the growth of plants in the less-weeded plots has again been catching up with that of the plants in plot A. Treatment A is no longer significantly better than either treatments B or C. Even in treatment D, the significance of the negative difference of the mean height of the cypress as compared with that under treatment A is much reduced.

Acacia melanoxylon has been subject to sambhur damage but to a much less extent than at any other centre. The higher incidence of the sambhur as indicated by the percentage of plants browsed in plots B and C as compared with plot A emphasizes rather than vitiates observations made above.

In September, 1940, plantations in plots A, B, C, and E were all doing excellently and crowns were closed or closing up. Plot D was the poorest as regards general conditions, being the most exposed to wind. The canopy in this plot is still open, but from all appearances will close in another year or two. The ground is well covered mainly by herbaceous weeds.

The results indicate here again that lower grades of weeding B, C, D, and E are all feasible. At the end of five years from planting there have been no significant negative differences between the mean heights of all the 3 test species in treatment B and C as compared with treatment A. Where significant, the difference has been in favour of treatment C. For all practical requirements, treatment C has scored as well or better than treatment A.

Ohiya

As in the sets of trials at the 3 other reforestation centres, treatments B, C, D, and E were all significantly poorer as regards the growth of all 3 test species in comparison with treatment A, and unlike them remained so at the last measurement. The survival percentages of the cypress and broad-leaved timber species were variable but on the whole satisfactory.

The *Acacia melanoxylon* had suffered considerable damage from browsing by sambhur. In this set of trials, unfortunately, the incidence of browsing as indicated by the percentages of plants browsed (*vide* Table II.), happens to be less in plot A than in the other plots and no conclusions are therefore possible as regards treatment effects on this species. Measurements of *Eucalyptus maculata*—*vide* Table III.—indicate, however, that there has been a general improvement of the relative mean height in the less-weeded plots B, C, and D as compared with plot A.

In September, 1940, plots given treatments A and B were very much the same in appearance. Both were good as regards stocking and general condition with canopy fully closed. Plots C and D appeared slightly poorer in height growth but still were quite satisfactorily established. Plot E, occupying a more favourable position, was better than the last two and canopy had fully closed up. In all the plots the plantation floor was adequately covered and protected.

The results of the investigations at this centre indicated that treatment A was significantly better than any of the other treatments. Judging, however, from the mean height growth, stocking and general conditions of the plantations at last measurements, the less-intensive forms of weeding have proved not inconsistent with the satisfactory establishment of plantations concerned in reasonable time.

Summarizing the results of the different sets of experimental trials conducted at the four reforestation centres, it will be seen that though there has been some inevitable plot and locality differences that have been influencing the treatment effects the following reasonably definite conclusions stand out quite clearly :—

I. At the end of the *third year* from planting the experimental plots at all but one centre, *i.e.*, Kandapola, have shown clean weeding to be significantly better than any of the other treatments.

II. At the end of the *fifth year*, however, there has been a general improvement of the less-weeded plots at all centres but one, *i.e.*, Ohiya, resulting in reduction of the initial differences of treatments B and C—particularly C—to statistical insignificance as compared with treatment A.

III. The mean heights and survival percentages of the constituent species together with the general conditions of the plantations raised under different treatments show that the lower intensities and frequencies have proved quite feasible and consistent with the intents and purposes of practical management.

IV. The period of weeding has been needlessly protracted in the past and that it need not under normal average conditions be extended beyond the 2nd or certainly the 3rd year from planting except, perhaps, for the lowest grade of weeding D.

V. Under average or normal conditions treatment C—strip-weeding in the first year and patch-weeding in the second—should be as acceptable as the present district practice of clean weeding as far as growth, stocking

and establishment of the plantations are considered, but is greatly to be preferred to clean weeding on the tenets of silviculture, soil conservation, and economics.

VI. Weeding costs in the past have been excessive and formed too high a proportion of the all-in-formation costs. Costings kept in these trials indicate that, under the most expensive form of weeding, costs need not be more than a fraction of estimated previous expenditure.

AFFORESTATION WEEDING TRIALS

Kinigama

At initial measurements, plots under treatments A and B were about equal as regards stocking and growth of all species. Actual differences between mean heights of both *Eucalyptus robusta* and *Eucalyptus maculata* in plots A and B were non-significant. All other treatments were, on the same basis, found to be significantly worse than either treatment A or B. It will be seen from Table I. that survival percentages were very satisfactory for all plots.

At final measurements, exactly the same relative differences between the several treatments remained. Treatments A and B showed no significant difference as regards height growth of the red-gum, and the difference of the mean heights of *Eucalyptus maculata* in the two plots was barely significant. All other treatments remained significantly worse than treatments A and B, and in the least-weeded plots a tendency to reduction of the relative differences in height is still noticeable, *e.g.*, plot E_1.

In September, 1940, plots A and B were much the same as regards height-growth and stocking. The crowns of trees in plot A were smaller (Crown : stem ratio : : 1 : 5 to 1 : 4) than those in plot B (crown : stem ratio : : 1 : 3 on average), and the canopy on the higher slopes was very open. The floor in plot A was for the most part naked and devoid of any ground cover. Leaf litter had been washed down slopes and accumulated on the gentler gradients at the bottom. In plot B there were faint contour ridges of scanty grass left from the strip-weeding in the second year, tending in places to hold up leaf litter. Unfortunately the alignments of some of the contour strips for weeding were not quite what they might have been. The canopy was on the whole closer and denser than in plot A. In plot E_1, adjacent to plot A, the canopy was just closing and plants, though smaller than in plots A and B, were looking vigorous and healthy. The floor had more pronounced contour ridges of grass which were effectively holding up leaf litter and checking surface soil wash. Plots C, D, and E_2 are on less favourable sites of poorer

soil conditions and it is fortunate both from the experimental and soil conservation view points that they received the less drastic forms of weeding. The eucalypts on the higher reaches of the plots are poor in condition and growth, better on the lower slopes and particularly in plot C where, though they are yet small, they appear to be vigorous and healthy.

The results of the experiments conducted at this centre indicate that :—

(*a*) Treatment A is not significantly better than treatment B.
(*b*) In the case of either treatment A or B fully-established plantations were possible within a period of 2 years.
(*c*) Under favourable soil conditions patch-weeding, strip-weeding and patch-weeding again in the first, second, and third year from planting has sufficed, *e.g.*, plot E_1.

Errabedde

At first measurement, very good stocking and mean heights were recorded in plots under treatments A, B, and C. Growth of all species in all plots was much better than in the corresponding set of plots at Kinigama. In respect of the growth of both *Eucalyptus robusta* and *Eucalyptus maculata*, treatments A and B showed no significant differences between them whilst all other treatments were significantly worse than either of these.

At final measurements, treatments A and B were about equal and still significantly better than any of the other treatments. The relative differences of mean heights of both species in these plots as compared with those of plot A were, however, noticeably reduced and appeared to show that, given time, these differences are likely to disappear altogether. The growth shown by even the least-weeded plot D is quite satisfactory.

In September, 1940, the plantation floor in plot A was bare except for patches of litter washed together by the rain and some bracken. The topmost surface soil on the slopes and the central ridge in the plot had been removed and the ground was hard and compacted. In the plot given treatment B conditions were similar but there was a better covering of leaf litter and more bracken. In plot C there had been very little surface wash and the floor was on the whole well covered with leaf litter, grasses, patches of scrub growth, other ground weeds, and various leguminous creepers. The growth was, of course, poorer than in the more-weeded plots A and B, but the chances appeared to be that the growth in this plot would eventually turn tables on those two plots. The plantation under treatment D had not yet closed cover as in plots A, B, and C but

the plants were growing vigorously and likely to cover up soon. The floor in plots D_1 and D_2 was well covered with weed growth and leaf litter. The surface soil was intact and there had been no appreciable quantity of soil washed from the weeded patches. In the plot given treatment E, the lower section by a stream was growing luxuriantly and the plantation even on the upper stony slopes was beginning to close cover. The floor was for the most part exposed and covered only by a scanty growth of grass and other weeds.

The results of the investigations here indicate that :—

(*a*) Under the more favourable conditions obtaining in these plots as compared with those at Kinigama, any of the lower grades of weeding tried would be feasible.

(*b*) Treatment A is not significantly better than treatment B, but both these treatments were significantly better than the other treatments up to the end of the 5th year of planting.

(*c*) The mean height growths of both *Eucalyptus robusta* and *Eucalyptus maculata* in the plots given the lower grades of weeding were satisfactory particularly for treatment C for which mean heights of 15·8 ft. and 14·4 ft. were recorded at first measurment and at final measurements 28·6 ft. and 22·3 ft. for *Eucalyptus robusta* and *Eucalyptus maculata* respectively.

(*d*) Soil conditions were better maintained in the less-weeded plots than in the more-intensely-weeded plots.

(*e*) Growth rates in the interval between first and last measurements were left relatively unimpaired by treatments and even better than in the period previous to first measurement.

It will be observed that, despite plot and locality differences, which here again fortunately favoured the more-intensely-weeded plots rather than the less-weeded plots but which could not naturally be eliminated or provided against using such large plots, there appear a number of definite conclusions that are yet fairly clear :—

I. There have been no admissible differences between treatments A and B at either Kinigama or Errabedde or at initial or final measurements in respect of the growth of either of the test species or stocking or general conditions of the plots concerned.

II. All the other treatments C, D, and E remained significantly worse than either of the first two treatments

but the growth rates of the plants in these plots showed an improvement in the second as compared with the first period of experiment (*i.e.*, before and after first measurement).

III. For general purposes, clean weeding in the first year and strip weeding in the second year should, from every plantation point of view, be as acceptable as the present management practice of continued clean weeding, and is very much to be preferred for other reasons. Under favourable conditions even treatment C should amply secure all plantation requirements and is to be preferred where its practice appears feasible.

IV. As in the case of the reforestation areas, the period of weeding has been needlessly protracted in previous management practice and under general average conditions need not extend beyond the second year or certainly not beyond the 3rd year from planting.

V. Total expenditure on the most intensive form of weeding has been but a fraction of the estimated expenditure previously incurred.

ABSTRACT

This note is concerned with weeding in the Timber and Fuel-plantations of the Up-country Division and experimental investigations conducted in the period 1935 to 1940 with a view to determining the minimum intensity, frequency, and period of weeding consistent with the satisfactory establishment of plantations in reasonable time.

Brief notes on the Up-country plantations, historical background of the practice of clean weeding and a description of its nature are given and the average total formation costs per acre on weeding for the decade previous to the initiation of the experiments estimated.

The principal locality and climatic factors bearing on the question of the type of weeding likely to be most suitable are examined and discussed. The rainfall conditions during the experimental period have not been specially favourable to the control of weed growth but have rather tended to be otherwise as shown by average rainfall statistics given.

The results obtained from observations carried out in 30 mainly large stage–II. experimental plots, to allow of costings, replicating 5 different treatments at 6 different plantation centres are examined and summarized separately for reforestation and afforestation centres. All measurements have been statistically evaluated and given in summary form in Tables I., II., and III.

The main conclusions are :—

(*a*) That the period of weeding ought under average conditions to be considerably shorter than it has been in the past and need not generally be extended beyond 2 or at most 3 years.

(*b*) That though clean weeding throughout has generally given significantly better results in the early life of the plantations, it does not maintain this advantage over the lower grades of weeding even in the 5th year from planting. Even where it does maintain this initial advantage significantly there are indications that the less-weeded plots are likely to overcome their initial handicap in time.

(*c*) That strip-weeding in the first year and patch-weeding in the 2nd (if necessary in the 3rd year) has in the main been no worse than clean weeding throughout, in the case of reforestation areas. This treatment is, therefore, recommended in view of other advantages principally of soil conservation and costs.

(*d*) That clean weeding in the first year followed by strip-weeding in the 2nd year has actually been no worse than continued clean weeding in the afforestation areas. For other cogent reasons, principally for maintenance of the already impoverished soil capital of the *patana* grasslands, this form of treatment ought to replace the present district management practice of clean weeding throughout period of formation.

(*e*) Consequent on the above conclusions, total formation expenditure on weeding need be but a small fraction of what such cost appears to have been in the past.

It is to the credit of the territorial officers on whom the responsibility for the executive work mainly rested that the investigations have been brought to a satisfactory conclusion despite this being amongst the first of anything like organized or detailed experimental investigations they have had to contend with. Sincere thanks are due for the co-operation and assistance of the Divisional Forest Officers who have held charge of the Division during the past 5 years, the territorial Forest Rangers and the Research Rangers who have been in charge of the field work.

TABLE I.

Expt. No.	Treatment.	Localities.	Date of Measurement.	Extent.	Survival Per Cent.	Mean Height in Feet.	Standard Error in Feet.	Difference of Means from A in Feet	Standard Error of Difference in Feet.	Survival Per Cent. of Timber Species.	Mean Height in Feet.	Standard Error in Feet.	Difference of Means from A in Feet.	Standard Error of Difference in Feet.
				Cupressus macrocarpa							*Acacia melanoxylon*			
F 11	A	Kandapola.	11. 3.38	5 ac.	84·4	5·5	± ·093	—	—	96·3	2·6	± ·139	—	—
12	B		17. 3.38	5 ac.	84·7	6·2	± ·102	+ ·708	± ·138 S	95·8	2·3	± ·101	— ·292	± ·172 NS
13	C		22. 3.38	5 ac.	86·0	5·8	± ·096	+ ·250	± ·134 NS	100·0	2·1	± ·098	— ·500	± ·170 S
14	D		19. 1.38	5 ac.	81·9	4·7	± ·083	— ·833	± ·125 S	100·0	1·9	± ·083	— ·667	± ·163 S
14*a*	E		10. 2.38	10 ac.	81·7	5·9	± ·073	+ ·417	± ·119 S	78·2	3·3	± ·162	+ ·750	± ·213 S
F 20	A	Conical Hill	7.11.38	4 ac.	84·6	9·4	± ·143	—	—	74·5	8·8	± ·358	—	—
21	B		7.11.38	4 ac.	88·5	7·2	± ·121	— 2·250	± ·187 S	70·5	8·0	± ·288	— ·750	± ·460 NS
22	C		7.11.38	4 ac.	84·7	6·8	± ·141	— 2·667	± ·200 S	60·9	7·4	± ·303	— 1·333	± ·468 S
23	D		29.10.38	4 ac.	77·2	7·3	± ·125	— 2·167	± ·189 S	68·4	5·3	± ·329	— 3·500	± ·487 S
23*a*	E		7.11.38	4 ac.	72·4	4·9	± ·102	— 4·500	± ·175 S	40·5	4·4	± ·171	— 4·333	± ·394 S
F 28	A	Pattipola-Ambawela	22.11.38	2·5 ac.	89·9	10·3	± ·218	—	—	85·0	14·3	± ·440	—	—
29	B		22.11.38	2·5 ac.	93·0	9·2	± ·174	— 1·167	± ·279 S	89·0	13·8	± ·488	— ·500	± ·658 NS
30	C		29.10.38	2·5 ac.	87·0	9·8	± ·211	— ·750	± ·303 S	85·0	6·8	± ·341	— 7·500	± ·557 S
31	D		29.10.38	2·5 ac.	91·7	8·5	± ·207	— 1·833	± ·300 S	90·3	6·3	± ·298	— 8·000	± ·531 S
31*a*	E		22.11.38	2·5 ac.	84·1	9·8	± ·179	— ·583	± ·283 S	83·8	6·8	± ·396	— 7·417	± ·592 S
U 6	A	Ohiya	23.12.38	5 ac.	69·0	8·9	± ·216	—	—	69·0	4·3	± ·354	—	—
7	B		23.12.38	5 ac.	85·7	8·2	± ·163	— ·750	± ·270 S	82·0	3·7	± ·524	— 3·583	± ·633 S
8	C		23.12.38	5 ac.	84·0	6·2	± ·183	— 2·750	± ·291 S	84·0	3·3	± ·089	— 5·167	± ·366 S
9	D		2.11.38	5 ac.	72·0	6·7	± ·198	— 2·250	± ·293 S	68·0	2·5	± ·211	— 5·875	± ·413 S
9*a*	E		17. 1.39	7 ac.	73·0	6·9	± ·182	— 2·033	± ·283 S	63·0	3·5	± ·108	— 3·208	± ·370 S
				Eucalyptus robusta							*Eucalyptus maculata*			
U 14	A	Kinigama	15.11.38	3·75 ac.	96·0	12·8	± ·348	—	—	84·0	13·0	± ·602	—	—
15	B		15.11.38	3·75 ac.	95·0	12·5	± ·436	— ·250	± ·558 NS	82·0	14·8	± ·680	+ 1·833	± ·908 NS
16	C		15.11.38	3·75 ac.	96·0	5·3	± ·183	— 7·417	± ·393 S	75·0	4·9	± ·302	— 8·083	± ·673 S
16*a*	D		23.10.38	3 ac.	90·0	5·3	± ·224	— 7·500	± ·414 S	82·0	5·4	± ·354	— 7·583	± ·698 S
16*bi*	E_1		8.11.38	2 ac.	85·0	8·7	± ·235	— 4·083	± ·421 S	67·0	4·3	± ·330	— 8·750	± ·686 S
bii	E_2		8.11.38		90·0	4·3	± ·124	— 8·417	± ·370 S	75·0	4·1	± ·265	— 8·917	± ·658 S
U 25	A	Errabodde	2.11.38	5 ac.	94·4	21·5	± ·507	—	—	62·3	19·3	± ·774	—	—
26	B		5.11.38	5 ac.	87·5	20·3	± ·450	— 1·250	± ·678	87·5	18·5	± ·370	— ·750	± ·858 NS
27	C		6.11.38	5 ac.	84·7	15·8	± ·378	— 5·667	± ·632	84·7	14·4	± ·533	— 4·833	± ·940 S
28	D		5.11.38	8 ac.	100·0	7·3	± ·254	— 14·250	± ·567	100·0	6·3	± ·768	—13·000	± 1·091 S
28*a*	E		19.11.39	5 ac.	100·0	18·0	± ·321	— 3·500	± ·600	—	No. Euc. maculata			
28*b*	D_2		19.11.39	4 ac.	99·8	13·0	± ·113	— 8·500	± ·519	100·0	10·8	± ·494	— 8·417	± ·918 S

TABLE II.

	Expt. No.	Treatment.	Localities.	Date of Measurement.	Mean Height in Feet.	Standard Error.	Difference of Means from A in Feet.	Standard Error of Difference.	Percentage of Sambhur Damage.	Mean Height in Feet.	Standard Error.	Difference of Means from A in Feet.	Standard Error of Difference.	Period of Weeding Years.	Total Weeding Costs per Acre.
				Cupressus macrocarpa						*Acacia melanoxylon*					Rs. c.
F	11	A	Kandapola	29.10.40	11·85	± ·447	—	—	95	4·36	± ·182	—	—	2	7 70
	12	B		29.10.40	12·83	± ·481	+ ·98	± ·657 NS	97	4·27	± ·161	— ·09	± ·243 NS	2	5 97
	13	C		29.10.40	12·26	± ·391	+ ·41	± ·594 NS	94	4·24	± ·217	— ·12	± ·283 NS	2	3 73
	14	D		29.10.40	12·63	± ·452	+ ·78	± ·636 NS	99	3·89	± ·148	— ·47	± ·235 NS	2	1 27
	14*a*	E		29.10.40	13·52	± ·546	+ 1·67	± ·706 S	36	13·27	± ·791	+ 8·91	± ·812 S	2	2 74
F	20	A	Conical Hill	31.10.40	12·62	± ·336	—	—	66	8·09	± ·455	—	—	2	13 21
	21	B		31.10.40	10·57	± ·285	— 2·05	± ·441 S	68	7·57	± ·409	— ·52	± ·612 NS	2	12 39
	22	C		31.10.40	12·56	± ·245	— ·06	± ·416 NS	59	8·08	± ·372	— ·01	± ·588 NS	2	13 67
	23	D		31.10.40	11·00	± ·276	— 1·62	± ·435 S	92	4·91	± ·217	— 3·18	± ·504 S	3	12 69
	23*a*	E		31.10.40	10·36	± ·263	— 2·26	± ·427 S	94	4·90	± ·212	— 3·19	± ·502 S	2	13 20
F	28	A	Pattipola-Ambawela	25.10.40	14·09	± ·317	—	—	18	15·49	± ·655	—	—	3	10 17
	29	B		22.10.40	14·03	± ·315	— ·06	± ·447 NS	32	12·35	± ·526	— 3·14	± ·840 S	3	10 37
	30	C		22.10.40	14·71	± ·464	+ ·62	± ·562 NS	36	13·12	± ·801	— 2·37	± 1·035 S	3	9 91
	31	D		22.10.40	12·65	± ·407	— 1·44	± ·516 S	83	6·02	± ·417	— 9·47	± ·776 S	3	9 91
	31*a*	E		25.10.40	12·11	± ·358	— 1·98	± ·479 S		(No. of Acacia melanoxylon inadequate)					
U	6	A	Ohiya	23.10.40	15·19	± ·440	—	—	70	7·35	± ·564	—	—	2	11 43
	7	B		23.10.40	11·68	± ·435	— 3·51	± ·619 S	96	3·41	± ·271	— 3·94	± ·626 S	2	10 75
	8	C		23.10.40	9·91	± ·375	— 5·28	± ·578 S	97	3·25	± ·146	— 4·10	± ·583 S	2	9 80
	9	D		24.10.40	10·02	± ·299	— 5·17	± ·532 S	90	4·04	± ·206	— 3·31	± ·600 S	2	8 96
	9*a*	E		24.10.40	10·95	± ·396	— 4·24	·592 S	98	3·28	± ·157	— 4·07	± ·585 S	2	7 68
				Eucalyptus robusta						*Eucalyptus maculata*					
U	14	A	Kinigama	11. 9.40	20·77	± ·286	—	—		24·76	± ·668	—	—	2	13 04
	15	B		11. 9.40	19·22	± ·596	— 1·55	± ·661 NS		22·57	± ·755	— 2·19	± 1·008 S	2	12 50
	16	C		26. 9.40	9·03	± ·303	— 11·74	± ·417 S		8·17	± ·385	— 16·59	± ·771 S	5	12 36
	16*a*	D		11. 9.40	8·84	± ·458	— 11·93	± ·540 S		10·33	± ·341	— 14·43	± ·750 S	5	9 43
	16*bi*	E_2		6. 8.40	9·49	± ·316	— 11·28	± ·426 S		8·42	± ·568	— 16·34	± ·877 S	5	11 9
	16*bii*	E_1		27. 9.40	17·94	± ·642	— 2·83	± ·703 S		9·50	± ·719	— 15·26	± ·981 S		
U	25	A	Errabedde	15.10.40	31·73	± ·705	—	—		26·96	± ·947	—	—	2	16 26
	26	B		16. 6.40	30·26	± ·288	— 1·47	± ·762 NS		25·15	± ·637	— 1·81	± 1·142 NS	2	13 56
	27	C		16. 6.40	28·60	± ·330	— 3·13	± ·778 S		22·32	± ·689	— 4·64	± 1·171 S	3	14 84
	28	D		28.11.40	15·50	± ·797	— 16·23	± 1·065 S		12·0	± ·970	— 14·96	± 1·356 S	5	—
	28*a*	E		29.11.40	25·05	± ·618	— 6·68	± ·939 S		(Number of Euc. maculata inadequate)				4	19 40
	28*b*	D_2		28.11.40	21·48	± ·346	— 10·25	± ·780 S		17·15	± ·543	— 9·81	± 1·045 S	5	—

TABLE III.—EUCALYPTUS MACULATA

Expt. No.	Localities.	Treatment.	Date of Measurement.	Mean Height in Feet.	Standard Error.	Difference of Means from A in Feet.	Standard Error of Difference.	Date of Measurement.	Mean Height in Feet.	Standard Error.	Difference of Means from A in Feet.	Standard Error of Difference.
			First Measurement (3 years old).					*Second Measurement (5 years old).*				
F 11	Kandapola	A	1. 3.38	8·38	± ·363	—	—	3.12.40	20·09	± ·449	—	—
12		B	16. 3.38	10·26	± ·435	+ 1·88	± ·567 S	3.12.40	19·54	± ·354	— ·55	± ·572 NS
13		C	22. 3.38	8·80	± ·344	+ ·42	± ·500 NS	3.12.40	16·21	± ·274	— 3·88	± ·527 S
14		D	19. 1.38	6·94	± ·392	— 1·44	± ·534 S	3.12.40	17·63	± ·332	— 2·46	± ·558 S
14*a*		E	10. 2.38	10·56	± ·319	+ 2·18	± ·484 S	3.12.40	23·37	± ·406	+ 3·28	± ·605 S
F 28	Pattipola-Ambawela	A	22.11.38	13·92	± ·391	—	—	22.11.40	17·30	± ·453	—	—
29		B	22.11.38	13·18	± ·456	— ·74	± ·601 NS	22.11.40	18·86	± ·446	+ 1·56	± ·636 NS
30		C	29.10.38	10·20	± ·361	— 2·72	± ·532 S	22.11.40	19·67	± ·492	+ 2·37	± ·669 S
31		D	29.10.38	9·89	± ·399	— 4·03	± ·559 S	22.11.40	12·16	± ·215	— 5·14	± ·501 S
31*a*		E	(No Euc. maculata)					(No Euc. maculata)				
U 6	Ohiya	A	23.12.38	16·68	± ·478	—	—	26.11.40	24·84	± ·503	—	—
7		B	23.12.38	13·00	± ·396	— 3·68	± ·621 S	26.11.40	23·22	± ·354	— 1·62	± ·615 S
8		C	23.12.38	11·53	± ·387	— 5·15	± ·615 S	22.11.40	18·51	± ·416	— 6·33	± ·653 S
9		D	2.11.38	10·71	± ·539	— 5·97	± ·720 S	22.11.40	19·43	± ·342	— 5·41	± ·608 S
9*a*		E	17.1.39	13·39	± ·411	— 3·29	± ·630 S	20.11.40	18·18	± ·326	— 6·66	± ·599 S

TABLE IV.—RAINFALL

Months	Kandapola				Conical Hill				Pattipola-Ambawela			Ohiya			Kinigama				Errabedde		
	Average from clearing to first measurement.	Average from clearing to final measurement.	Average at station for 3¼ years.	Mean average for 10 years.	Average from clearing to first measurement.	Average from clearing to final measurement.	Average at station for 3¼ years.	Mean average for 20 years.	Average from clearing to first measurement.	Average from clearing to final measurement.	Mean average for 10 years.	Average from clearing to first measurement.	Average from clearing to final measurement.	Mean average for 27 years.	Average from clearing to first measurement.	Average from clearing to final measurement.	Average at station for 3¼ years.	Mean average for 30 years.	Average from clearing to first measurement.	Average from clearing to final measurement.	Mean average for 20 years.
January ..	11·93	8·98	7·14	12·20	4·56	3·66	2·70	5·70	9·08	8·10	12·20	8·90	6·47	11·05	7·32	5·11	2·43	8·52	2·00	3·58	7·53
February ..	6·71	5·86	7·19	3·99	3·85	3·39	3·06	2·39	7·21	5·70	3·99	9·39	6·46	2·74	10·39	6·89	7·30	3·55	5·75	4·72	2·72
March ..	5·37	4·14	3·39	5·14	4·80	6·73	6·17	5·20	10·94	8·50	5·14	6·75	4·97	6·85	10·28	7·39	6·64	7·15	6·53	4·05	5·43
April ..	6·53	9·24	13·15	5·88	8·41	7·95	10·46	6·90	8·21	10·40	5·88	8·76	12·17	8·97	12·37	13·37	15·07	8·97	7·87	9·15	6·36
May ..	7·06	8·08	8·38	8·41	10·20	13·41	10·81	11·43	6·18	4·83	8·41	6·45	8·53	6·62	4·90	5·62	5·45	5·49	11·20	6·29	5·58
June ..	1·87	3·40	3·53	4·39	11·69	12·88	16·39	12·89	4·46	4·97	4·39	2·02	1·91	3·20	1·32	2·14	2·27	1·56	4·22	4·25	1·35
July ..	3·97	3·82	3·89	4·55	19·71	16·54	17·13	11·34	6·76	6·53	4·55	5·36	3·87	3·64	3·33	3·08	2·19	2·56	7·26	1·64	1·47
August ..	3·04	3·13	3·84	5·09	8·43	8·97	9·03	11·13	3·74	4·44	5·09	3·15	2·67	2·80	4·19	3·47	4·26	3·25	4·92	2·64	2·45
September ..	5·73	6·32	6·29	6·72	11·75	10·43	10·99	10·25	7·96	7·92	6·72	9·44	6·89	5·36	10·64	7·60	4·83	5·05	6·76	4·41	4·39
October ..	7·59	6·38	5·85	8·48	8·63	9·35	9·76	11·80	6·21	6·04	8·48	7·10	6·34	11·08	6·24	6·67	8·73	10·85	5·61	6·77	9·25
November ..	10·80	9·98	11·63	10·64	9·72	10·34	10·90	9·91	10·04	9·33	10·64	8·93	10·51	10·51	12·70	12·67	13·57	12·69	1·89	9·83	10·44
December ..	15·93	17·13	14·49	10·38	8·02	5·86	6·30	5·41	14·55	12·75	11·38	17·18	13·97	14·01	12·96	10·69	6·38	11·15	1·81	8·82	8·32
	86·18	87·18	88·77	85·87	109·78	109·51	113·70	104·35	93·34	89·51	85·87	93·43	84·76	86·83	96·64	84·70	79·06	80·79	65·82	66·15	65·29

DEPARTMENTAL AND OTHER NOTES

MARMALADE MAKING FROM CEYLON CITRUS FRUITS

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CITRUS fruits available for marmalade making in Ceylon include oranges, grapefruit, lemons and limes. The bitter orange generally grown is larger than the Seville orange and, although it does not give such a high quality product, is probably the best fruit in Ceylon for "everyday" marmalade. Sweet oranges and mandarin oranges can be combined with other citrus fruits to give variety of flavour. Lemons are mainly used with the other fruits to add acidity and limes can be similarly used, although they by themselves make an attractive marmalade. Grapefruit marmalade is a pleasant change from bitter orange marmalade.

The fruit used should be ripe, or very slightly under-ripe, never over-ripe as over-ripe fruit will not give a good set. The skin should be of good colour and free from blemishes.

The set or gel of marmalade depends upon the presence in the fruit of a substance known as pectin which occurs mainly in the white pith forming the inner layer of the skin. In the process of marmalade making this pectin must first be extracted from the fruit and then combined with the correct quantities of sugar and acid to give the gel. Many marmalade recipes wrongly recommend that the white pith should be left out, which means that very little pectin remains and consequently the marmalade will not set. The amount of pectin present in any one kind of fruit varies with the ripeness of the fruit and also with the conditions under which it has been grown. But the amount of pectin controls the amount of sugar to be used. Thus it is obvious that if marmalade is made from a recipe, without allowance for pectin variation, results will sometimes be good and sometimes poor. Therefore it is necessary to test in a simple manner whether much or little pectin is present.

To Test for Pectin.

In the process of marmalade making, which will be given in practical detail later, the first stage is to boil the fruit in water until the peel is soft and the pectin extracted. The concentration of pectin in the liquid should then be tested as follows: —

Take a teaspoonful of liquid from the pan and place in a glass tumbler. Allow it to cool and then add to it three teaspoonfuls of methylated spirits and stir gently to mix. This precipitates the pectin as a jelly-like clot. If there is plenty of pectin present the clot will be a solid lump and about the size of the teaspoonful of liquid taken (Pl. I., fig. 1A); with less pectin the clot will be broken into several pieces and smaller in amount (Pl. I., fig. 1B) and with a still smaller proportion of pectin numerous small lumps, not forming a clot at all, will appear (Pl. I., fig. 1C). If a good pectin clot is obtained 1–1¼ lb. of sugar should be added to 1 lb. of pulp in the pan. With only a moderate clot ¾–1 lb. of sugar can be added or further boiling given to concentrate the pectin. If the clot is poor and further boiling will reduce the liquid too much in proportion to the peel, the only thing to do is to add pectin from some other source. The easiest way of doing this is to boil the peel of some other citrus fruit in water for about two hours and then, after testing it for pectin, add the liquid to that in the pan.

Sugar.

Sugar is the preservative in marmalade and the finished product should contain 60–65 per cent. of it. Some of it is present as invert sugar. Ordinary granulated sugar is quite suitable for marmalade making and it is unnecessary to buy more expensive sugars which are sometimes recommended.

Acid.

Acid helps to extract pectin from the pith, is necessary in combination with pectin and sugar to form the gel, and adds to the flavour of the marmalade. Some citrus fruits require the addition of acid and this is usually added, at the beginning of the process, in the form of lemon or lime juice, but sometimes as citric or tartaric acid. With a little experience the degree of acidity can be estimated, sufficiently accurately, by taste.

Practical Marmalade making.

There are many individual preferences in marmalade making. Some people like the peel cut fine, others prefer it coarse; some like a clear jelly marmalade, others a thick marmalade; some like to boil the fruit whole and cut up the peel afterwards, others to cut it at the beginning and so on. All these variations cannot receive separate treatment here but as long as the general principles are understood and followed the marmalade will be a success.

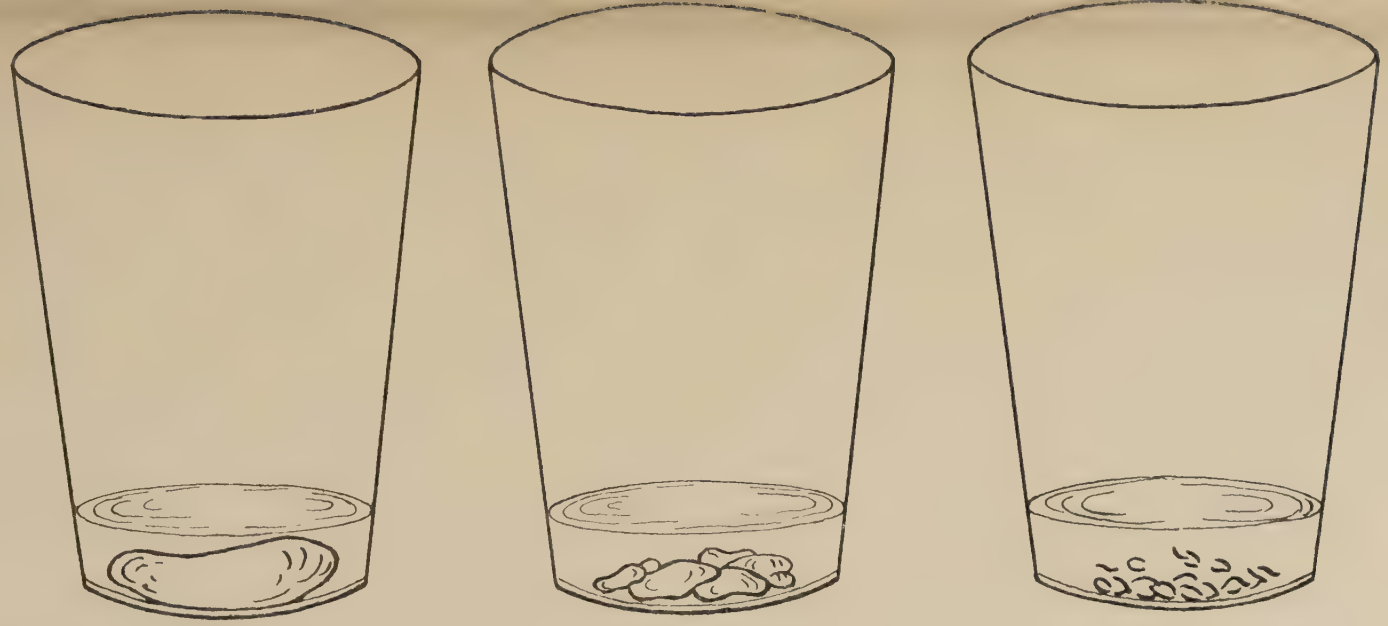

Fig. 1

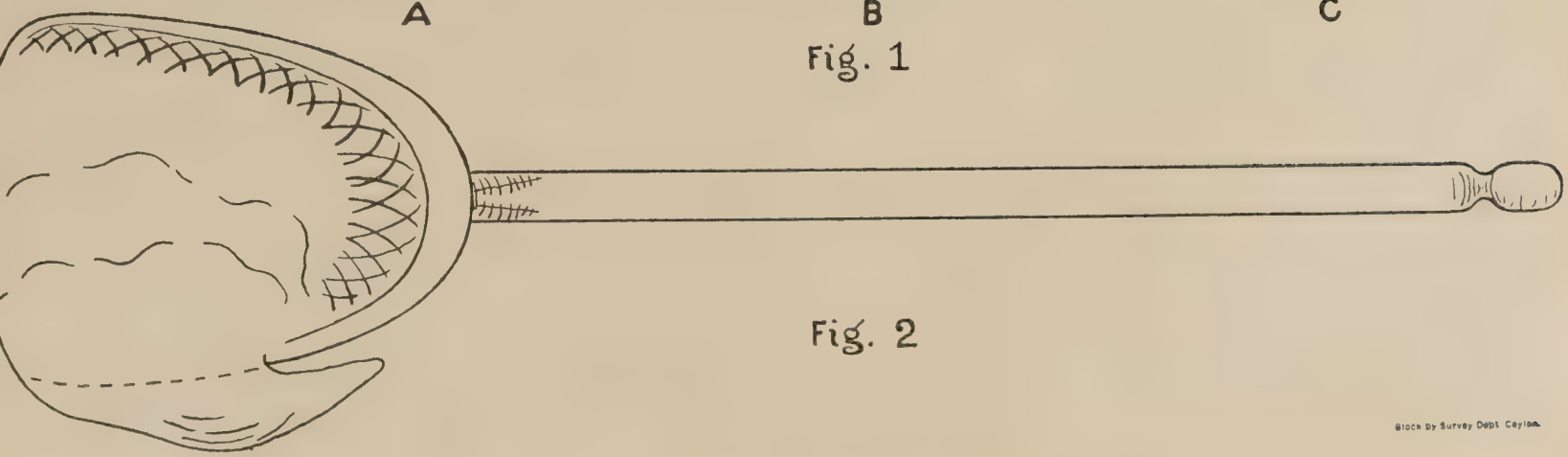

Fig. 2

Block by Survey Dept Ceylon.

PLATE I.—MARMALADE MAKING.

Fig. 1.—Testing for Pectin.

Fig. 2.—" Flake " test to determine if the Marmalade is sufficiently boiled.

Cutting and Soaking the Fruit.

The fruit is first weighed then peeled and the peel sliced finely or coarsely as desired and placed in a large basin. The rest of the fruit is cut into rather small pieces and tied in a muslin bag which is placed with the peel in the basin, together with any juice draining out of it. If desired the white pith may be removed from the peel before cutting in which case it should be cut finely and also put in the muslin bag. Any added acid is put in at this stage and if lemon juice is used the lemon peel is cut into small pieces and included in the muslin bag. Water is now added, the usual amount being 2 pints to 1 lb. of fruit. More can be put in during boiling if it is necessary. The basin is covered to keep out dust and left to stand overnight. This soaking helps to soften the peel and shorten the subsequent boiling but can be left out if marmalade has to be made in a hurry.

Boiling and Addition of Sugar.

An aluminium pan is probably the best; copper, brass and enamel are quite satisfactory, but iron should not be used as it may give the marmalade a metallic taste. The pan is first weighed, the contents of the basin poured in and brought to the boil. Slow boiling is continued until the peel is quite soft. At intervals during boiling, the muslin bag is pressed with a wooden spoon to squeeze out juice and pectin from it. As soon as the peel is soft the pectin test is taken. If it is satisfactory the pan is removed from the heat, the muslin bag well squeezed and extracted from the pan and the pan again weighed. As was mentioned above the weight of pulp thus obtained determines the amount of sugar to be added. The pan is replaced on the heat, the sugar added and the mixture again brought to the boil. To prevent burning it is stirred with a wooden spoon until the sugar dissolves. At this stage the marmalade is boiled as quickly as possible, as a short boiling, once the sugar is added, is essential for bright colour and good flavour.

Finishing Point.

There are several methods adopted for telling when the marmalade is sufficiently boiled. The most usual method is to take out a small amount, put it on a cold plate to cool, and then see if it sets. In a hot country this may take some few minutes and meanwhile the marmalade in the pan may be over boiled. A similar type of test is the " flake " test. The wooden stirring spoon is dipped into the marmalade and taken out with some marmalade adhering to it. It is then held horizontally over a plate away from the heat and rotated to cool it. When the marmalade is ready it will not drop from the spoon in single drops, but first hang in a sheet and then flake off (Pl. I., fig. 2). This test is quicker than the former but the most reliable method

of obtaining the end point is by weight. It has been previously mentioned that the finished marmalade should contain 60 per cent. or thereabout of sugar for the sake of good keeping. If the correct amount of sugar, as given by the pectin test, has been added this concentration also gives the right set. Thus if the weight of sugar added is 60 per cent. of the marmalade, the weight of marmalade = weight of sugar $\times$ 10/6. As the weight of the pan has previously been taken the marmalade is boiled until it attains this weight.

Putting into Jars.

As soon as the marmalade is sufficiently boiled it is taken from the heat and immediately skimmed. Scum should not be removed during boiling or a good deal of marmalade will be wasted. It is then allowed to cool for several minutes, stirred well to distribute the peel, and poured into clean warmed jars. The jars are filled right to the top as marmalade shrinks on cooling, and, while it is still very hot, a waxed paper circle, cut just the size of the inside rim of the jar, is placed flat on the surface. The marmalade is then allowed to stand until quite cold when covers are put on the jars.

Marmalade made in this way will keep for many months in the jars. It should be stored in as cool and dry a place as possible, preferably away from the wall, in a store cupboard which is in a part of the house protected from the direct rays of the sun.

Note.

No recipes are given here, as it has already been explained that marmalade of uniformly good quality cannot be made by rule-of-thumb methods. However the following notes on mixtures of fruit may be of help to the inexperienced.

Bitter Orange Marmalade.

Use one lemon to two bitter oranges.

Grapefruit Marmalade.

Use one lemon to two grapefruit.

Mandarin Orange Marmalade.

Use one grapefruit and two lemons to 2 lb. of mandarin oranges. This is best made as a jelly marmalade. Cut about three quarters of the peel of the mandarin oranges and tie in a muslin bag. Remove this after boiling and strain the juice from the rest through a jelly bag. Then pour the juice back into the pan, put in the peel from the muslin bag, add sugar as required and finish in the usual way.

Lime Marmalade.

Use limes only, or one grapefruit to one dozen limes.

Lemon Marmalade.

Use lemons only, or one grapefruit to six lemons.

SUGAR-CANE IN CEYLON : A HISTORICAL SURVEY

IN these notes, an attempt is made to summarize briefly the progress of sugar-cane cultivation in Ceylon from the earliest times from which records are available up to the present day.

EARLY SUGAR-CANE PLANTATIONS

It has been stated that sugar-cane was grown in Ceylon in the days of the Sinhalese kings even before the Dutch era, but no details of such cultivations are available.

The systematic cultivation of the crop was established in Ceylon during the early part of the last century. It was grown in various districts of the Island, in the Southern Province near Baddegama on heavy loams (paddy soils), at Jaffna, Northern Province (calcareous loams), at Anuradhapura, North-Central Province (heavy loams over gravel), and in the Eastern Province at Allai (medium loams).

The pioneers in sugar-cane cultivation, however, did not find the undertaking very successful and by the time of the Great War 1914–18, the plantations had either been entirely abandoned or re-cultivated in tea and rubber. The following extract from the Ceylon Observer Handbook and Directory furnishes some particulars regarding the early sugar-cane plantations :—

> " The systematic cultivation of sugar-cane was previous to the present (twentieth) century attempted twice on a large scale in Ceylon in the neighbourhood of Kalutara. Mr. Winter planted and grew canes near Kalutara in 1826 and manufactured sugar therefrom but transferred his operations to Baddegama near Galle in 1840 upon an old indigo estate that he purchased. Mr. Tytler was employed in cane cultivation for Messrs. Acland and Boyd in 1837–40 in Dumbara and Messrs. Baring Bros. opened Peradeniya Estate in sugar in 1840. Between 1842 and 1846 large sugar plantations were formed in the Southern Province, viz., Oodagama on the Gintara river by Baron Delmar, Hahangam near Galle by Baron Delmar, Telicada on the Gintara river by Messrs. Faulkner and Liverpool, Kohila Wagura at Ambalangoda by Messrs. Tindall and Co., Paraduwa near Matara by Lord Elphinstone, Wilpitiya on the Matara river by Mr. Greg. Small plantations were opened near the Gintara river by

Mr. A. Orr and at Watteraka by Mr. Palmer. There were also several sugar plantations in the Eastern Province, viz., Dalloopatugedera, Katukanda, Dambawinna and Etgala.

In 1860, however, the only places where systematic cane cultivation was being carried on were Paraduwa, Baddegama, Etgala and Peradeniya. Within a few years after 1860 the only estate carrying on sugar cultivation was Baddegama in the Southern Province.

The reasons assigned for the previous failure of sugar-cane ventures was the poor quality of the juice of canes grown in the Southern Province. Plantations were situated in the regions receiving a rainfall of between 100 and 150 inches of rain and juices were said to test between 6–9° Beaumé. In the Western Province, coconuts were found to grow better than canes and rapidly replaced the cane cultivation in 1860".

FIRST TRIALS WITH SUGAR-CANE

The first experiments with sugar-cane conducted by the Department were at the Experiment Stations at Peradeniya and Anuradhapura in 1920. The varieties tried included Sealy's Seedling, 55P, 3390, D.K. 74, Red Top Mauritius, San Nombre and Striped Tanna.

Yields of cane per acre varied from 45·8 tons per acre with Sealy's Seedling to 20·8 tons with 131P at Peradeniya, and 30·8 tons per acre with Sealy's Seedling to 2·4 tons with Striped Tanna at Anuradhapura. The sucrose percentages varied from 11·4 to 20·2 at Peradeniya and 11·6 to 20 at Anuradhapura.

These trials were continued in 1921 and 1922 and the results were published in *The Tropical Agriculturist*, Vol. LVI., 1921, p. 205–210, and Vol. LIX., p. 205–207.

The trial plots at Peradeniya and Anuradhapura were maintained for the purpose of multiplication of the better varieties and issue to planters, but were eventually discontinued owing to the absence of public interest in the crop.

DROUGHT-RESISTING SUGAR-CANE

Prior to 1918, the Ceylon Sugar Refineries, Ltd., had conducted experiments with drought-resisting canes like Red and Striped Mauritius, Yellow Caledonia, the results of which led them to believe that such canes might prove a profitable crop in Ceylon.

HIGH LAND SUGAR-CANE

An interesting trial cultivation of high land cane was undertaken by Mr. A. W. Winter, the Baddegama planter, in 1920–21. On his estate Pillagoda Valley he had already tried the varieties

Striped White Tanna, DK 74, B. 3390, 55P, 131MP, Seely's Seedling and San Nombre. He also had a small estate at Ganewatta where he was cultivating sugar-cane.

His trial was more in the manner of a speculative commercial enterprise rather than a planned trial for the purpose of scientific observation. It was, however, the first attempt to grow sugar-cane on high land in Ceylon and for that reason merits notice.

In 1920 he applied to the Director of Food Production for the lease of some land in Ratmarathimbillakanda in Gangaboda pattu, Southern Province, for experimental purposes with high land cane. This land was visited by the Director of Agriculture and he reported favourably on the high land cane already being experimented with at Pillagoda Valley. Mr. Winter applied for an area of 100 acres to start with. The lease was approved by the Governor in 1923 on the understanding that only sugar-cane was to be grown on the land.

By July 1923, about 100 acres of land were leased by Mr. Winter and in May, 1924, a further 100 acres were leased by him. In October, 1928, Mr. Winter reported to the Director of Agriculture that the returns on his cultivation were not sufficient to pay for the harvesting of the cane and the manufacture of sugar at the prevailing prices and that he had lost about 2 lakhs of rupees in the venture about the success of which he was now pessimistic. He stated that the canes " did not grow to any length and the quantity of cane was nothing like what it ought to be nor the quantity of sugar for a given quantity of juice ".

The Divisional Agricultural Officer visited Mr. Winter's estate and factory in November, 1928, and reported that the growth of the cane on high-land was very variable and, especially in the ratoon crop, did not appear to be satisfactory. He stated that the growth of cane was not as good as that on low-lying land and the sucrose content was low. The extension of cultivation on the high land was not recommended.

SUGAR COMMITTEE OF THE BOARD OF AGRICULTURE

In the Annual Report of the Department of Agriculture for 1917 it was stated that " some investigation had been made into the possibilities of a sugar industry for the Colony " and that it was thought that such an industry could be established with advantage. It was also suggested that at the commencement it would possibly have to be an industry for small growers and to require some assistance from Government in its initial stages.

In view of the entire dependence of the Island upon imports for its supply of sugar, this was followed in May, 1918, by the

appointment of a Committee by the Board of Agriculture to consider the prospects and possibilities of sugar-cane cultivation and of the manufacture of sugar in Ceylon. This Committee included in its consideration the possibility not only of producing sugar in the Island, but also of exporting sugar, thus satisfying the desire of the Imperial authorities to produce an adequate supply of sugar within the Empire.

The Committee met thrice. It considered details concerning the former sugar-cane cultivation and some of the members examined the prospects of sugar-cane cultivation along the banks of the Gin-ganga, at Kalupahana in the Province of Uva, under irrigation in the North-Central Province, and under the proposed Allai Extension Scheme in the Trincomalee District in the Eastern Province.

At that time the sugar-cane cultivations in Ceylon generally consisted of small gardens adjoining dwelling houses in villages. There were two centres for growing sugar-cane for the manufacture of sugar—at Nagoda in Galle District and at Kalupahana in the Province of Uva. At both these centres there was an area of 30–40 acres under cultivation. The cane was crushed in bullock or hand-power mills to prepare a raw sugar. At Nagoda some clarification of this preparation was carried out to produce a fine-grain raw sugar, while at Kalupahana cakes of cane jaggery were manufactured. It was reported that at Kalupahana the cultivation of sugar-cane was of the most primitive type undertaken by estate labourers—the Bourbon variety of cane being grown. The yield of canes was very poor and the Committee of the Board of Agriculture stated that, with improved methods of cultivation, a two-fold increase in the yield could have been expected.

At Nagoda and along the banks of the Gin-ganga nearly 300 acres had at one time been under cultivation. The estate of Messrs. Winter and Bowman was originally 100 acres in extent, but it was later planted up with tea and rubber and the sugar-cane abandoned. The reasons for this were : (*a*) the decrease in the price of sugar, (*b*) the low sucrose content of the canes, (*c*) the increasing cost of labour, (*d*) difficulty with regard to fuel, and (*e*) the higher profits derived from tea and rubber. The varieties of canes grown at this centre were Bourbon and Striped Singapore.

The Committee, having reviewed the existing cane cultivations, concluded that more extensive areas in Ceylon would be capable of being cultivated with sugar-cane with profit, for example in the Kurunegala District, Southern, Sabaragamuwa and Uva Provinces, and along the banks of the Mahaweli-ganga. The Committee, however, did not recommend that large areas under tanks be exclusively devoted to sugar-cane cultivation since

the growth of paddy on these areas was also necessary and important; but it pointed out that a satisfactory rotation of sugar with paddy or other food crops had been worked out in Java. The Allai Extension Scheme was specially mentioned as worthy of development for sugar-cane cultivation.

TRIALS AT ALLAI

The suggestion of trying out the possibilities of sugar-cane cultivation at Allai had been before the Director of Agriculture for a number of years. It was believed that, should the Scheme prove of definite promise, capitalist concerns would be attracted to undertake large-scale plantation at Allai.

The question of labour was also examined by the Director of Agriculture, but it was his opinion that there should be no difficulty in securing labour from Batticaloa.

The Allai Tank consisted of a large area of some 10,000 acres of practically flat land situated near the east coast of Ceylon, south of Kottiar Bay and Trincomalee harbour. About 3,277 acres forming the bed of the former Allai tank, most of which was free of trees or jungle growth, used to become flooded to a depth of one or two feet during the north-east monsoons in December–January, but the water gradually subsided with the irrigation of 2,000 acres of paddy below the tank bund. Under the Scheme it was proposed to utilize the tank bed and surrounding land for cultivation.

In August, 1920, as a result of the recommendation of the Sugar Committee, the Director of Agriculture suggested to the Ceylon Government that the Allai Extension Scheme be closely examined by sugar experts with practical commercial experience in other tropical countries and proposed that financial interests prepared to finance large sugar-cane plantations be introduced. This was followed by an invitation by Mr. (now Sir) F. A. Stockdale, Director of Agriculture, to Mr. C. F. Hughes, Managing Director of the Colonial Sugar Refinery Co., Sydney, Australia, to examine the Allai Extension Scheme for sugar-cane plantation.

Mr. Hughes visited Allai in November, 1924, and reported that about 7,500 acres of the Scheme may be suitable for cane growing of which Crown land consisted of 5,000 acres. He also reported that the "general configuration of the area appeared almost ideal for the purpose of growing sugar-cane under irrigation and with modern conditions of cultivation". He advised that the first step to be undertaken was to ascertain what varieties of cane were likely to yield the best sugar results under local conditions by planting in several experimental plots the more promising of the canes cultivated at Peradeniya and Anuradhapura.

This recommendation was similar to that of the Committee on the proposals for the development of the Economic Resources of the Colony reproduced below :

"*Sugar-cane Cultivation.*—This Committee entirely endorses the recommendation of the Conference that the Department of Agriculture should carry out experiments on the cultivation of sugar-cane on a sufficiently extensive scale to demonstrate whether such cultivation is commercially possible. It will be seen on reference to page 52 of the minutes of the second meeting that the proposals made by Mr. Stockdale for carrying out the experiments would involve the cultivation of two areas of about 20 acres each, one in the dry zone and the other under a tank. He estimates the cultivation charges at Rs. 350 per acre, and the cost of the outfit required for dealing with the output of an area of 20 acres at Rs. 10,000. The cost of the experiments apart from the value of the land would then be (Rs. 350 by 40) plus Rs. 20,000=Rs. 34,000. In view of Ceylon's annual consumption of 40,000 tons of imported sugar, we are of opinion that an expenditure of Rs. 40,000 to 50,000 from revenue on experiments which might demonstrate the possibility of local production of this quantity at a cheap price as that now paid for imported sugar would be fully justified." (Government Sessional Paper VI. of 1921).

The Director of Agriculture examined the question with the Divisional Agricultural Officer, Northern Division, and arrived at the opinion that two blocks of 10 acres would be sufficient to begin with—one to be in the jungle land and the other in the low-lying, more swampy area—and suggested that the trial should last for three years. He recommended that this be done early so that the mill qualities of the various canes which will be experimented with be thoroughly investigated. Provision for the trials was included in the Estimates of 1924–25.

Two blocks of land were selected in April, 1925, and an Agricultural Instructor was stationed at the trial area in August, 1925. However, only one block was cleared and developed.

Planting commenced in November, 1925, and 11 varieties of cane were grown. Cuttings of these varieties were obtained from the Experiment Station, Peradeniya and Anuradhapura. Further planting was continued periodically up to October, 1926. Irrigation had to be carried on at regular intervals from March to September inclusive, and this was provided by means of a Persian wheel.

RESULTS OF ALLAI TRIAL

Harvesting of the 1925 planting commenced in July, 1927, and extended to the middle of October. The usual Indian

method of manufacturing cane-sugar jaggery was adopted. The ratoon crop was cut in July–September, 1928, and the results are given below :

	Ratoon Crop	
	Canes (Tons)	Jaggery (Tons)
Barbados 208	14·2	1·3
Striped White Tanna	19·5	0·8
San Nombre	32·1	2·2
Barbados 3390	22·9	1·3
Mauritius 131P	10·5	0·8
Mauritius 1237	21·8	1·2
Striped Tanna	14·0	0·9
Demerara 74	30·6	1·2
Cheribon	11·7	0·5
Mauritius 55P	23·9	1·5

The average yield per acre of the total areas cut were :

Virgin crop —Canes		35 tons
	Jaggery	2·45 ,,
Ratoon crop—Canes		20·1 ,,
	Jaggery	1·17 ,,

The detailed analysis of canes produced and the Profit and Loss Account were published in Government Sessional Paper L. of 1928.

The Director of Agriculture made the following statements regarding the results obtained at the Allai Trials :

(i.) The system obtaining in Java of rotating sugar-cane with paddy should be reported upon by an officer of the Department of Agriculture.

(ii.) Success in sugar-cane growing will not be achieved unless capital is available for the manufacturing side of the industry.

(iii.) In Allai itself success cannot be achieved unless the land can be adequately drained and flooding prevented.

(iv.) If the drainage is good, there are decided possibilities before the cultivation of sugar-cane in the Allai area.

Note.—Mr. L. Lord, an officer of the Department of Agriculture who visited Java in 1929 to study rice cultivation there, was directed to include in his study sugar-cane also ; but unfortunately Mr. Lord's experience could not be turned to advantage owing to his resignation from the service of the Government.

The experiment at Allai was finally closed in September, 1930.

RECENT TRIALS AT KILIVEDDY

With the conclusion of the Allai trial no further systematic experiments with sugar-cane were undertaken until in June,

1937, the Research and Experiment Committee of the Department of Agriculture assigned to the Botanist of the Department the two following experiments with the crop :

(i.) An experiment to determine the best variety of cane to be grown, from the standards of yield and sugar content.

(ii.) An experiment to compare the yield and sugar content of imported varieties of sugar-cane.

The locality of the trials was to be Kiliveddy which is situated near Muttur, Trincomalee District.

Thirty-eight Varieties of sugar-cane which consisted of 12 Coimbatore varieties and others from Java, Federated Malay States, Mauritius, South Africa, Queensland, and Hawaii were included in field trials. The trials commenced in September, 1939, and are expected to continue for a period of about five years before provisional conclusions can be published by the Botanist.

ARTIFICIAL INSEMINATION OF COWS.

It is notified for general information that owners of cattle who are desirous of getting their cows impregnated by the above method should communicate with the Veterinary Research Officer, Peradeniya, who will provide them with further particulars on the subject.

The following scale of fees will be charged for insemination with effect from June 1, 1941 :—

	Rs.	c.
To places within 10 miles from Peradeniya ..	4	0
,, ,, ,, 20 ,, ,, ,, ..	8	0
,, ,, ,, 30 ,, ,, ,, ..	10	0
,, ,, ,, 50 ,, ,, ,, ..	12	50

If a reinsemination is found necessary the owner should pay half the above rates provided it is done within 60 days of the first insemination.

M. Crawford,
for Director of Agriculture.

Peradeniya, May 22, 1941.

SELECTED ARTICLES

CINCHONA IN GUATEMALA*

THE comprehensive summary of recent progress in cinchona cultivation throughout the world published in the bulletin of the Imperial Institute, 1939, includes only brief mention of the work which has been done in the Republic of Guatemala. Since those experiments show considerable promise, it is hoped a general survey of results obtained to date may prove of interest.

BOTANY

To render intelligible this discussion it is necessary to consider briefly the botanical status of the plants grown as sources of the drug quinine. Weddell, who devoted exhaustive study to the genus Cinchona in the early days, published in 1848, a list comprising 21 species. Later, in 1870, he revised his classification, extending it to include some 37 species and 15 subspecies. Many of these, in the light of later study, seem more properly to be considered as geographical forms or varieties. The summary made by the Imperial Institute, mentioned above, states :—

" Four species only have been cultivated to any extent as a source of alkaloids. These are *C. ledgeriana* Mœns ex Trimen (known also as *C. calisaya* Wedd. var *ledgeriana* Howard) from which Ledger Bark is obtained ; *C. succirubra* Pavon ex Klotsch, the source of Red Bark ; and finally *C. calisaya* Wedd. and *C. officinalis* Linn., yielding Yellow Bark, and Crown Bark or Loxa respectively. Two hybrids may also be mentioned, namely *ledgeriana* × *succirubra*, known as ledger hybrid or sometimes as *C. hybrida*, and *officinalis* × *succirubra*, which is usually called *C. robusta*. At the present time practically the entire supply of cinchona bark in commerce is obtained from *C. ledgeriana* and *C. succirubra*. "

This classification, though greatly reducing the confusion in which the subject was left by the early botanists, is considered by certain American students as requiring still further simplification. Paul C. Standley, who has devoted much study to the Rubiaceæ of tropical America, reduces the species involved in commercial quinine production to *C. officinalis* Linn. and *C. pubescens* Vahl (*C. succirubra* Pavon), justifying his stand in the following words (*cf. the Rubiaceæ of Ecuador*, Field Museum of Natural History, Publication No. 285, Chicago, 1931) :

" Because of the great economic importance of the trees concerned and especially because of the varying quinine content in the inhabitants of the various regions, several botanists have devoted a great deal of time and hundreds of printed pages and plates to a discussion of the species of the genus. The result of their work has been the description of a great number of so-called species, based on characters that certainly would not be considered valid or important in other genera of the Rubiaceae. The writer has examined a large

* By Wilson Popenœ (United Fruit Co.) in *Tropical Agriculture*, Vol. XVIII, No. 4, April, 1941.

amount of herbarium material of the genus, as well as photographs of many of the types involved. He is quite unable to discover any conservative basis for recognizing the many species to which names have been given, and he believes that these names relate to variable races of a few not very clearly marked species which may be recognized for botanical convenience. The mere fact that the variations of these races are important from the stand-point of the pharmacist does not justify their recognition, if such were possible, as species in the ordinary sense of that term."

Admittedly the last word has not been said regarding the botanical status of those forms of cinchona which yield quinine commercially. Admittedly further study may alter the classification adopted by Standley. But the simplification of the agricultural problem by the elimination of numerous questionable species, which do not invariably come true when grown from seed, seems so logical and so practical that Standley's classification has been accepted by those working in Cinchona in Guatemala at the present time. *C. ledgeriana* is therefore not recognized as a species; neither is *C. calisaya*. Both are forms of *C. officinalis*, a widely variable species which hybridizes freely with the other one which produces commercial quinine—*C. pubescens* (more commonly known as *C. succirubra*), giving rise to forms which often go under the name of *C. robusta* but which more properly are to be termed *officinalis* × *pubescens* hybrids.

Agriculturally, it is becoming the practice in Gautemala to refer to trees of the species *officinalis* as calisayas; those of the form known elsewhere as *C. Ledgeriana* as Ledgers or calisayas of the Ledger race; trees of the species *pubescens* as succirubras; and all hybrids between *officinalis* and *pubescens* as hybrids rather than *C. robusta*. Without presuming to say that this terminology will stand test of the future botanical investigation, it is felt that its simplicity recommends it.

HISTORICAL

The stimulation of interest in Cinchona culture shortly after the middle of the last century, resulting from the successful efforts of the British and the Dutch to transplant Cinchona trees from their native home in the Andes to plantations in the Eastern tropics, had repercussions in several regions, of which Guatemala seems to have been one. For we can only attribute to this cause the introduction of Cinchona into this country about the year 1870, a work which seems to have been fostered by that remarkable man, President Justo Rufino Barrios. Details are difficult to obtain at this late day, but it is known that Barrios planted cinchona extensively on his property "El Porvenir" in the Department of San Marcos, where the progeny of his original trees still grow in vast numbers. An examination of these half-wild trees to-day suggests that Barrios brought in both *C. officinalis* and *C. pubescens*. As would be expected, the latter is the one which has survived, most of the present trees being unquestionably of that species; but there are sufficient indications of *calisaya* blood to convince one that hybridization has taken place, and that while the more delicate *officinalis* has disappeared, its memory still lingers in the narrow, smooth leaves, the white flowers and the relatively high quinine content of numerous trees scattered over the slopes of the valcano Tajumulco which dominates this beautiful property.

Shortly after the death of Barrios the Reformer a serious effort was made by Germans to establish Cinchona cultivation in the Department of Alta Verapaz of which we fortunately have an account in the memoirs of Franz Sarg, published in " Deutschtum in der Alta Verapaz " 1938. Sarg states that the Minister of Agriculture, Don Manuel Harrera, offered a prize of fifteen hundred pesos to the man who would make the first planting of two thousand trees. Through the good offices of Prince Nikolaus of Nasuas seeds were obtained from Ceylon in 1878, and in 1882 the prize was claimed and paid. Difficulty in handling the bark, and falling prices in the world market, discouraged the undertaking and the project was dropped. But two old trees at the Finca Sachamach, near Coban, still remain to testify that here again the effort was not limited to the introduction of the relatively inferior succirubras, but that calisayas also were involved ; for these two trees, which may be seedlings of some of the first ones planted, show definite evidence of *calisaya* blood—again in their leaves, their flowers, and their relatively high quinine content.

After these early efforts, from which no pecuniary profit seems ever to have been derived, interest lasped for half a century. Then, with a view to developing a Cinchona industry capable of supplying the North American market with quinine, experiments were started which had the support of the Guatemala and the United States governments. Seeds of the Ledger race were obtained, and later, through the good offices of the Division of Plant Exploration and Introduction of the United States Department of Agriculture, other promising strains were brought into the country. Nurseries were established in several places ; Don Mariano Pacheco, Director General of Agriculture for the Republic of Guatemala, gave the subject his personal attention ; and work was under way which in the past two years has commenced to show promising results.

COMMERCIAL CINCHONAS AND THEIR CHARACTERISTICS

Naturally, these recent experiments in Guatemala have had as background the available literature upon the general subject of cinchona cultivation in other regions, particularly Java, which at present supplies 95 per cent. of the world's quinine. The literature, while by no means extensive, is sufficient to point out the objectives which must be attained if success is to be achieved. Of particular value has been W. N. Sand's account of the Cinchona Industry in Java, published in the Malayan Agricultural Journal, 1922 ; and " De Kinacultuur " by A. Groothoff, published in Haarlem, Holland, in 1925. A more recent work of value, from a different region, is E. H. J. Stoffels' bulletin " Le Quinquina ", published by L'Institut National pour l'Etude Agronomique, Belgian Congo, 1939.

These publications by no means exhaust the list, of course, and it is perhaps well to mention once again the excellent summary compiled by the Imperial Institute, referred to at the beginning of this paper. From this last-named publication, and bearing in mind the fact that the Ledger race of *calisaya* is today the source of most of the quinine produced commercially, the following quotation is of more than passing interest :—

" It has already been mentioned that *C. ledgeriana* is more exacting in its requirements than any other species. The most suitable climatic conditions

for satisfactory bark production of high quinine content would appear to be those obtaining in Java at elevations of 4,000 to 5,000 feet. The character of the soil is also of great importance in the case of this species ; its first essentials are that it should be friable and of good depth, the best results in Java having been obtained on such soils recently cleared of forest. Other species, especially *C. succirubra*, on the other hand, will thrive and give relatively good yields of alkaloids under conditions where *C. ledgeriana* would fail. For this reason, and owing to the uncertainty of successfully re-establishing *ledgeriana* on old cinchona lands attention has been paid to the question of grafting the latter species on the more vigorous *succirubra* stock. This has proved highly successful and practically all the Ledger bark now being produced in Java is harvested from grafted trees."

Work in Guatemala commenced with full appreciation of the fact that experimentation is required to determine which kinds are best suited to profitable commercial exploitation under the particular conditions of soil and climate existing in this country ; but also, with understanding that high-yeilding Ledgers such as those grown in Java have fully demonstrated their value and might here prove to be the best. More time will be required to determine for any given area just what is right. The situation, so far as can be judged at long range (since Java is accepted as the guide), sums itself up about as follows :—

Ledger seedlings on their own roots.—These are held to be the ideal thing, where conditions for their development are satisfactory. They have the advantage that root-bark as well as stem-bark contains relatively high percentages of quinine, whereas Ledgers grafted on *succirubra* rootstocks suffer from the disadvantage of the relatively low quinine content of the root-bark. There is the further advantage that the expenses of grafting is avoided.

Ledger clones on succirubra roots.—These can be grown on soils not sufficiently rich for Ledgers on their own roots. Vegetative propagation provides foreknowledge regarding quinine content of the ultimate tree, a distinct gain since it is a notorious fact that Cinchona seedlings are in nearly all instances subject to much variation.

Calisayas other than those of the Ledger race.—These were given a trial in the Asiatic tropics before the advent of Ledgers (the history of which is too well known to require mention here), and the fact that Ledgers have completely superseded them speak volumes. Nevertheless, the literature makes little mention of new trials in the past half century, and there seems a definite possibility that the Andean region, native home of the Cinchonas, may still yield forms of *C. officinalis* which, under certain conditions of climate and soil, will have commercial value.

Succirubras on their own roots.—These are of more rapid growth than Ledgers, and can be cultivated successfully on many soils not suited to the latter ; but their quinine content is low and they are not considered commercially very satisfactory—except where there is an interest in alkaloids other than quinine, such as cinchonidine and quinidine, of which succirubras sometimes contain relatively large percentages.

Hybrids, C. officinalis × C. pubescens.—These are frequently mentioned in the literature and there can be no doubt that some of them have played a part in commercial production. Many have the advantage of being more robust than Ledgers, and of more rapid growth. As a rule, their quinine content is lower than that of good Ledgers ; but the volume of bark produced at a given age may be considerably greater, hence the lower quinine content is in part offset. There is the added circumstance that hybrids often grow well on soils which will not support Ledger seedlings. Due to their mixed genetic constitution, however, it seems probable that it will be necessary to graft hybrids on to succirubra stocks if uniformly good results are desired.

RESULTS OF EXPERIMENTATION TO DATE

The pioneering done in the 1870's and 1880's has left large numbers of Cinchonas—mostly succirubras, with a few evidence of calisaya blood at Coban and El Porvenir—scattered over Gautemala, chiefly in the Alta Verapaz and on the coffee plantations of the Pacific side. But the information gained in the early days regarding the adaptability of Gautemalan soils and climates to the culture of calisayas is lost. Present efforts to determine the commercial possibilities of Cinchona culture in this Republic have had to be based on the fact that nothing is known and everything is to be learned.

Seeds of high-grade Ledgers were obtained and nurseries formed at several places which in the light of information gleaned from the literature seemed promising. Lack of experience naturally resulted in the loss of many seedlings ; but sufficient were saved to plant several small experimental areas, chiefly at Finca Halvetia (Department of Retalhuleu) Finca Samac (Alta Verapaz) Finca El Zaptoe (Escuintla) and Finca Panamá (Sololá). These plantings ranged in elevation from 3,500 to 4,500 feet, and represented a very considerable range of climatic conditions.

Many of these trees have attained sufficient size to show interesting responses to environmental conditions, and to permit of bark analysis. Best growth has been obtained on the brown, deep, volcanic fine sandy loams and silt loams of the Pacific side, and on the alluvial clay loams of the Coban region. On the black sandy loams—one of the chief soil types of the Pacific side—results have not been so good ; though it may be noted that in all cases these Ledger seedlings have been planted on land which for many years previously had grown coffee or other crops.

Since writers on Cinchona cultivation in Java repeatedly stress the necessity of using virgin lands for Ledger seedlings, it cannot fairly be said that experience in Gautemala on old lands of the black sandy type is discouraging.

In considering the results of bark analyses it must be remembered that samples are taken from precisely that part of the tree which contains the highest percentage of quinine, namely the trunk at about three feet from the ground. Bark from the smaller branches does not show such high percentages, nor does that from the roots. On the basis of the available literature, Ledger seedlings which show 12 to 13 per cent. of quinine sulphate when bark-sampled at the age of five to six years can be considered good ; and such trees are now growing in Guatemala.

From these trees it should be feasible not only to develop satisfactory sources of high-grade seed for further planting, but also; and perhaps even more important, select the most vigorous and disease-resistant individuals, and those with the thickest bark, for the establishment of clones to be propagated by grafting on succirubras. Not a few such clones have already been chosen and are being propagated as rapidly as possible. W. N. Sands (*loc. cit.*) has enumerated the principal factors which should be taken into account when selecting individual for vegetative propagation, and his description of the Java technique has been accepted as the best guide until such time as adequate experience has been gained locally.

In addition to trees of Ledger race now established in Guatemala there are numerous others obtained from several sources through the co-operation of the United States Department of Agriculture. And there are many seedlings from the old trees at Sachamach near Coban, broad-leaved forms of apparently mixed blood, vigorous in growth and suitable for cultivation on lands not rich enough for Ledger seedlings. Some of these, and some of the broad-leaved trees presumably of hybrid origin which have been introduced from other regions, have shown quinine contents of 6 to 7 per cent., which is considered satisfactory in view of their rapid growth and thick bark.

Unfortunately, the altitudinal range of the first experimental plantings does not include elevations above 4,500 feet. Recently, therefore, small plantings have been made at higher levels—up to 6,200 feet in one instance—to test the possibilities of the zone immediately above that in which coffee is profitably grown in this republic. For it will greatly facilitate the development of Chincona industry if coffee planters can use for this crop lands between 5,000 and 6,000 feet in elevation. Many planters possess such lands which because they were not considered suitable for coffee are still in virgin forest.

PROPAGATION

The production of *succirubra* seedlings on which to graft Ledgers offers few difficulties. Successful production of Ledger and other *calisaya* seedlings, on the other hand, requires good technique and attention to details ; while grafting is in this case, as with many other trees, something which can be successfully carried out only when it is backed by a certain amount of experience and knowledge of essential factors.

To the experienced horticulturist, in other words, there is nothing in the propagation of Cinchona, asexually or sexually, which presents serious problems; but the tropical agriculturist accustomed only to the simpler techniques of cane, coffee or banana culture (for example) will find the propagation of Cinchona difficult until he has devoted much time to a conscientious study of details.

Seed Beds.—The basic principles underlying the propagation of Cinchona from seed appear to be these : the seed must be kept uniformly moist while they are germinating, and should be given very little light. If allowed to dry out once they have commenced to swell, they die. Immediately they have germinated, they are endangered by the risk of " damping off " against which they must be protected by a delicate adjustment of light and ventilation,

assisted in some instance by a judicious use of Bordeaux mixture. In a few weeks' time they are out of danger, so far as damping off is concerned, and must be given more light, gradually, without exposing them to the direct rays of the sun.

The type of seed bed used in Guatemala differs in no major respect from that described in the literature ; indeed it has been patterned after the latter. Obviously, local experience is still meagre in this as in many other respects. Protection from the sun is usually provided by sheet-iron (" lamina ") roofing which is easily obtainable in most parts of tropical America and which can be used repeatedly for many years. Seed bed should not be wider than three or four feet : the length is optional. The roof should have a steep slope, from north (the higher side) to south. It is important that good ventilation be provided on both sides, and the bed should run from east to west so that light can be admitted, in gradually increasing intensity, on the northern side without letting the sun have direct access to the plants. During the first few weeks (germination usually takes place in 20 to 30 days) the beds are kept dark by using bamboo mats, canes or other convenient material along the northern side. Adjustment from time to time permits the necessary increase of light as the plants develop and require it.

The beds are surfaced with an inch or two of rich forest loam or leaf-mould. The seeds are sown at the rate of two to three grams per square yard of surface (a gram contains 2,000 to 3,000 Ledger seeds) : if sown more thickly, it has been found that the danger of damping off is greatly increased. Though it is not necessary to cover the seed with soil, it is local experience that drawing a very fine-toothed rake gently over the surface after sowing, aids in securing a good germination.

Nurseries.—The time which must elapse before seedlings are ready to be transferred from seed beds to nurseries varies greatly with the climate—in other words, the altitude above sea level. In general it ranges between six and ten months. Before they are moved, the seedlings—which should be about two inches high—are hardened gradually by exposure to more light. If not sufficiently hardened, moving is fraught with considerable risk of loss. If hardening is attempted too suddenly—that is, if the plants are exposed to the full force of the sun's rays—the risk is just as great.

Nursery beds are carefully prepared and provided with shade of some sort to reduce the amount of light which reaches the young plants at the start. Here again experience and assiduous attention to details are essential. Plants are spaced 2 × 2 inches to 6 × 6 inches apart, the spacing depending upon the size they have reached at the time they are moved, and the programme to be followed later : if spaced closely a second transplanting is necessary, since 6 × 6 inch. spacing is required during the few months before the trees are ready to be transferred to permanent locations in the field.

Fortunately Cinchona seedlings, if properly grown and " hardened off " transplant very readily, even when moved, with bare roots.

Grafting.—The technique at present employed in Gautemala is that which has been developed by Jorge M. Benitez, Plant Propagator of Experimental

Plantations Inc. at Finca El Naranjo, Chicacao—principal base of experimental Cinchona cultivation in this Republic.

It differs slightly from standard practice in Java if one can judge by published descriptions of the latter.

The essentials of grafting seem to be these : stock plants (invariably of the species *pubescens* or *succirubra*) must be strong and vigorous, with stems one-half to three-quarters of an inch in diameter at the ground. Scions must be of sound, half-ripened wood. And the work should be done in damp weather if best results are expected.

In other words, the principals are the same as with other trees, and are familiar to horticulturists. The percentage of success varies, however, with different varieties, the strong-growing hybrids such as those known in several countries as " robustas " being much easier to graft than the more delicate Ledgers.

Young trees in vigorous growth provide better scions than older trees. Blossoming wood should not, of course, be used. The scions should be about four inches in length, and of the thickness of a lead pencil. They do not need to be terminals, but should have two nodes towards the upper end. The leaves are carefully trimmed off with the grafting knife and a diagonal cut about two inches in length is made toward the lower end. This cut is placed against a long shallow cut on the side of the stock-plant, so that the cambium layer of the scion comes into direct contact with that of the stock. Holding the scion firmly in place with one hand, the graft is then bound with waxed tape, made by boiling cheap muslin in a mixture of beeswax and resin. After this is done, the graft is covered completely with warm melted wax applied with a one-inch brush.

Union takes place in four to six weeks. After the scion has commenced to grow vigorously, the stock plant is cut back gradually. In about one year's time the grafted plant is ready for moving into its permanent location in the field.

The best months for grafting in Gautemala are considered by Benitez to be June and July, though the work can be done very satisfactorily at any time between the onset of the summer rains in May and the season of heavy rains in September-October.

FIELD CULTURE

Obviously, Guatemala lacks extensive experience regarding this subject. Plantings now being made are spaced variously, from a minimum of 4 × 4 feet to a maximum of 10 × 10 feet. Practice in Java—again as described by Sands and others—suggest close planting and later thinning out for the exploitation of the bark. The culture given in the field is much the same as that used for coffee—another rubiaceous plant—primarily because this technique is familiar to Guatemala agriculturists.

Little is known, as yet, regarding pests and diseases which must eventually be faced by the Cinchona planter in this country. It seems usually to be the case that enemies develop more abundantly when their host plants are cultivated on an extensive commercial scale.

CULTIVATION OF CASTOR SEED IN BRAZIL*

CULTIVATION of Castor Seed in Brazil.—Of the two chief countries exporting castor seed (*Ricinus communis* L), India and Brazil, the latter has become increasingly important in recent years on account of greater proportions of the Indian crop being utilized in the country of origin. In 1931, for example, India exported 117,000 tons of the seed and Brazil 19,000 tons. By 1938 the position had completely reversed, India exporting only 9,000 tons in that year, whilst the Brazilian export had risen to 124,000 tons.

In Brazil the crop is considered to give the best results when grown in a moist tropical climate with the rainfall well distributed over the year. Even in a tropical country it does not do well at too high an altitude, or under insufficiently damp conditions ; whilst if the climate is too cold, although a satisfactory vegetative growth may be obtained, the yield may be adversly affected.

The crop is cultivated in the agricultural zones of the north-eastern states, in the same area in which maize is widely grown and its cultivation has also spread to the south of the country. In the valley of the San Francisco River the castor bean grows wild and the produce of the wild plant is harvested. It is also cultivated in this region.

The crop does well in the coastal districts, and in these areas it may, in the absence of frost, persist for several years. In such localities a tall growing variety may be employed. The plant is reported to be intolerant of a heavy dew-fall, and may be adversely affected by low temperature even in the absence of actual frost.

Although the castor plant may survive for from five to ten years it is normally cultivated as an annual, though in some cases it appears that the crop may be left for two seasons. It is often grown in rotation with cotton, in which case it is advised that a green-manure crop should be taken in between.

Three general types of plant are recognised, the tall, medium, and short. These vary in height from 5 ft. up to some 30 ft. or more. The seeds are from ⅓ in. to 1 in. in length, with many variations of colour.

In normal circumstances it is the short or " low " types that are cultivated, and of these two varieties " Caturra " and " MC " are mentioned as being useful kinds, and also as being reasonably resistant to frost. A number of selected strains of the different types have also been produced by the Agricultural Institute, Campinas, S. Paulo.

An important point in choosing a variety is that the husks should not split too readily so that a large portion of the crop is lost before harvest. Generally

* Extract from the *Bulletin of the Imperial Institute*, Vol. XXXVIII, No. 3, July–September 1940.

speaking the short varieties do not split before harvest. With these the seed weight is roughly half a gram, and the oil content is about 50–60 per cent. A medium variety is " Bourbon " the seed of which have an oil content of about 63 per cent. The seeds of the tall varieties average round about a gram in weight. A tall variety whose seeds do not split in the field is " Zanzibar ". In general, however, the tall varieties have this defect. An additional disadvantage of the tall kind is the difficulty encountered in harvesting due to their great height. Also as a general rule the oil-seed trade does not like the large seeds.

In general, results depends much on choosing the right variety. This can only be done by tests in the country of production. It has been found, for example, that varieties which give satisfactory results in one district may be comparative failures when tried in a different locality.

The castor plant will grow in almost any soil, but for profitable cultivation it is necessary to have good average land. Thus a sandy loam, containing humus and lime, is found to be satisfactory. Strongly calcareous, clay, peaty, sandy, waterlogged or cold soils are all less suitable, though excessive dampness can be corrected by drainage. The crop does well on flat valley soils, and on land bordering rivers.

Soils deficient in lime should be lightly limed about every three years. Freshly cleared forest land may be most advantageously first utilised for other crops as otherwise the castor plant tends to run too much to foliage. In any case the land should be capable of ploughing to a depth of about 9 in.

It is suggested that as castor is an exhaustive crop it is not well suited to inter-cultivation. However, in India, the crop is not normally grown as a pure stand, but is commonly intercultivated, or grown round the borders of the farms.

The castor crop make good use of farmyard manure or of compost, and has a high nitrogen requirement. Green manure crops such as mucuna and crotalaria may be employed with advantage to save the cost of other fertilizers.

It is calculated that a crop of 1,800 lb. of castor seed per acre removes from the soil approximately 54 lb. of nitrogen, 22 lb. of phosphoric acid, 16 lb. of potash, and 5 lb. of lime. A suggested manurial dressing is 8 tons of farmyard manure plus 90 lb. each of superphosphate of lime and potassium chloride per acre. Alternatively, 900 lb. of castor seed cake may be employed with 180 lb. of superphosphate of lime and 90 lb. of potassium chloride. Manuring must be adapted to the requirements of the particular soil, but a complete manurial dressing is recommended to obtain the best results.

Before the crop is sown the land should be ploughed twice in different directions and a good seed bed prepared. Authorities seem to agree that a thorough and deep cultivation of the soil prior to planting is advisable, and it is probably essential to the profitable cultivation of this crop under Brazilian conditions. The seed may be drilled but is usually planted in rows by hand ; it should not be sown broadcast.

In central and southern Brazil sowing takes place during the months of September and November, for preference after a spring rain. The spacing adopted varies according to the type, and also to some extent with the fertility of the soil, the wider of the following spacings may be employed on rich land.

Short types	..	40–80 in. × 70–80 in.
Medium types	..	70–100 in. × 90–120 in.
Tall types	..	80–120 in. × 120 in.

Three to four seeds are put in at each stand and are covered to a depth of about 2 in. The crop is thinned to one plant per stand as soon as it is strong enough, *i.e.*, when the plants are about 1 ft. in height. With the short types from 5 lb. to 7 lb. of seeds is required to plant an acre, and an average return is given as 1,600 lb. per acre, though the yield may be as low as 700 lb., and as high as 2,650 lb. per acre in exceptionally favourable circumstances.

The land should be kept free from weeds by cultivation until the crop is approximately 40 in. in height, at which stage the castor plants shade the land. It is advised that the plants should be topped when about 3 ft. in height, though not all authorities consider topping necessary with the short types. This operation serves to keep the bushes low, with facilities for harvesting.

At harvest the capsules are removed from the plants by cutting and the seed may be separated from the husks by beating at this time. Varieties such as "MC" with which shedding in the field does not occur, are best left until all the fruits are ripe.

The crop is quite frequently harvested when about three-quarters of the fruits are ripe; the remaining capsules will ripen during drying. It is important, however, not to cut the fruits earlier as there will be a loss in the yield of oil obtained if too high a proportion of unripe fruit is harvested. After harvest the fruits are spread out in the sun to dry and split. Splitting may have to be assisted by threshing, though in normal circumstances, if the crop is picked in dry weather and spread out in the sun, the capsules split satisfactorily. The seed can be readily separated from the husks, though the crop may be beaten to facilitate this operation. If the crop is harvested when damp, trouble in separation may be experienced. With large plantations some form of artificial drying equipment may have to be provided on account of the size of crop to be handled.

The presence of broken seeds and rubbish lowers the value of the seed, and these are usually removed by winnowing before the crop is bagged. The seed may be graded according to size, and for storage purposes a dry ventilated building should be employed.

While many insects live on the castor plant in Brazil it is reported that none of these do any damage of serious economic importance. There are no widespread diseases affecting the castor crop in that country, though in certain circumstances severe damage is experienced from *Botrytis* sp. while leaf spot is common.

MEETINGS, CONFERENCES, &c.

MINUTES OF THE FIFTY-SIXTH MEETING OF THE RUBBER RESEARCH BOARD HELD AT THE CHAMBER OF COMMERCE, COLOMBO, AT 2.30 P.M. ON MONDAY, APRIL 21, 1941.

Present.—Mr. E. Rodrigo (in the Chair) ; Mr. C. E. Jones (Deputy Financial Secretary) ; Mr. T. Amarasuriya ; Mr. W. P. H. Dias, J.P. ; Mr. L. M. M. Dias ; Mr. T. C. A. de Soysa ; Mr. J. D. Farquharson ; Mr. L. P. Gapp ; Mr. R. C. Kannangara, M.S.C. ; and Mr. F. A. Obeysekera.

Mr. T. E. H. O'Brien, Director, was present by invitation.

Apologies for absence were received from Meessrs. J. A. S. Agar ; F. H. Griffith, M.S.C. ; R. J. Hartley ; N. D. S. Silva, O.B.E., J.P. ; E. C. Villiers, M.S.C. ; and E. W. Whitelaw.

1. MINUTES.

(*a*) Draft minutes of the meeting held on January 20, 1941, which had been circulated to members, were confirmed and signed by the Chairman.

(*b*) Matters arising from the minutes :

Coagulants—

Reported that new legislation would be required before the import of sulphuric and other mineral acids could be controlled. After discussion it was decided that further action in the matter be postponed, and that propaganda for discouraging the use of proprietary coagulants be undertaken by the Smallholdings Department.

2. DECISION BY CIRCULATION OF PAPERS.

Training of Rubber Tappers—

Reported that, as approved by circulation of papers, a memorandum had been sent to the Minister for Labour, Industry and Commerce, expressing the view that Rubber tappers could not usefully be trained at Dartonfield.

3. BOARD.

The Chairman reported the following changes in membership since the last meeting :—

(*a*) Resumption of duties as Chairman by Mr. E. Rodrigo from February 25, 1941.

(*b*) Nomination of Mr. C. E. Jones, Deputy Financial Secretary, to represent the Financial Secretary in place of Mr. S. Phillipson, from February 19, 1941.

(*c*) Renomination of Mr. E. C. Villiers as one of the representatives of the State Council for a further period of three years from February 16, 1941.

(*d*) Renomination of Mr. L. P. Gapp by the Ceylon Estates Proprietary Association for a further period of three years from April 1, 1941.

(*e*) Nomination of Mr. J. A. S. Agar by the Ceylon Estates Proprietary Association to act for Mr. J. C. Kelly during the latter's absence from the Island with effect from April 3, 1941.

4. EMPLOYERS' PROVIDENT FUND.

On the proposal of the Chairman it was decided that the Board should resume the administration of the Fund under the old rules, subject to a change in the rate of contribution from 5 to 7½ per cent. Amendments to rules 3 (i) and 3 (ii) were also approved.

5. EXPERIMENTAL COMMITTEE.

Recommendations made at meeting held on March 17, 1941 :—

(*a*) *Export of Latex.*—Decided to increase the year's output of preserved latex from Dartonfield to 40,000 lb. (dry rubber), including 20,000 lb. to be purchased from outside estates. A vote of Rs. 8,500 was approved to meet the extra expenditure.

(*b*) *Estate Cart road.*—Decided to accept the offer of the Kalutara D. R. C. to metal, tar, and maintain the approach road, subject to the payment of a first and final contribution of Rs. 6,550 towards the cost of the work. It was also decided to accept the contribution offered by Gallawatta estate towards the cost of the work.

(*c*) *Over-expenditure of estate votes.*—Covering sanction was given for the over-expenditure of Rs. 3,696 on estate votes in 1940.

(*d*) *Buildings.*—The following votes were approved :—

	Rs.
Double cottage for Ceylonese labourers with well and 2 latrines ..	1,651
Extension of bungalow servants' quarters (2 rooms) ..	827
Manure shed at Nivitigalakele	67 (Supplementary)
Water tank at Nivitigalakele	350

(*e*) *Exchange of clones with Proefstation West Java.*—A proposal made by the Proefstation West Java, for the exchange of new clones between the two Institutes, was approved in principle.

(*f*) *Clone museum at Kepitigalla estate.*—Noted that the proposal for the establishment of a clone museum at Kepitigalla estate had been approved by the Directors of the Kepitigalla Estate Co. The Director was authorized to arrange for an area of eight acres to be replanted during the N. E. planting season, subject to approval of the estimates by the Experimental Committee.

(*g*) *Verification of Stores, 1940.*—The Director's report on the verification of stores, 1940, was adopted.

(*h*) *Malaria Control Scheme.*—Agreed that the Board should continue to subscribe to the Malaria Control Scheme on an annual basis.

6. SMALLHOLDINGS COMMITTEE.

Minutes of the meeting of the Smallholdings Committee, held on March 18, 1941, were adopted.

7. ACCOUNTS.

(*a*) Statement of Receipts and Payments of the Board for the quarter ended December 31, 1940, was approved.

(*b*) Balance Sheet and Auditor's Report for 1940 was approved, and it was noted that the surplus at the end of 1940 was Rs. 215,006.

(*c*) *Excess expenditure and savings on votes.*—The statement of Excesses and Savings on votes for 1940 was approved, and covering sanction granted for excess expenditure amounting to Rs. 9,467.

(*d*) Dartonfield and Nivitigalakele accounts for November and December, 1940, and January, 1941, were tabled.

(*e*) *Investment of Rs. 40,000.*—The Chairman reported that Rs. 40,000 had been invested in the Ceylon Government 2½ per cent. War Loan, 1948.

(*f*) *Fixed Deposits.*—The Chairman reported the renewal of the following fixed deposits :—

(1) Rs. 30,000 at the Chartered Bank of India, Australia and China for 12 months from February 5, 1941, at 1¾ per cent. per annum.

(2) Rs. 15,000 at the Bank of Ceylon for 12 months from April 10, 1941, at 1¾ per cent. per annum.

(*g*) *Supplementary Votes.*—The following supplementary votes were passed, to meet the cost of works approved at the meeting held on January 20, 1941 :—

	Rs.
Junior Staff Bungalow at Dartonfield	4,500
Kitchen hearths in labourer's quarters at Dartonfield and Nivitigalakele	1,380

8. REPORTS.

(*a*) Director's Report for the quarter ended December 31, 1940, was approved.

(*b*) Annual Report for 1940, was approved and it was agreed that it should be published as usual.

9. STAFF.

(*a*) *Mr. R. K. S. Murray.*—Reported the departure of Mr. R. K. S. Murray on leave for 8 months from April 16. Arrangements were made for carrying on the work of the Botanical and Mycological Department during his absence.

(*b*) *Mr. M. W. Philpott.*—Reported that the departure of Mr. M. W. Philpott on military service had been cancelled, on official representations that his technical services were likely to be required in Ceylon.

(*c*) Junior Staff

(*a*) *Appointments.*—The appointment of one Rubber Instructor (new appointment) and one Laboratory Assistant (replacement) were reported.

(*b*) *War allowance.*—An interim report of the Committee appointed to consider the salaries and terms of service of the Junior Staff was considered, and it was decided that a war allowance, on the terms approved for Government servants, be paid to officers in receipt of a monthly salary of Rs. 100 or less, with effect from March 1, 1941.

10. LONDON ADVISORY COMMITTEE FOR RUBBER RESEARCH (CEYLON AND MALAYA).

(*a*) *Annual Contribution.*—Decided that the Board's contribution, at the present rate of £875 per annum, be continued on a yearly basis from 1942.

(*b*) *Changes in membership.*—The following changes were reported :—

Advisory Committee—

(1) Dr. H. A. Tempany nominated by the Colonial Advisory Council of Agriculture and Animal Health in succession to Sir Frank Stockdale.

(2) Death of Sir Herbert Wright, one of the representatives of Ceylon planting interests. It was decided to record the Board's appreciation of the services of Sir Herbert to the Ceylon Rubber industry.

Technical Sub-Committee—

(1) Death of Mr. B. D. Porritt.

(2) Dr. S. Pickles appointed in place of Mr. W. G. Smith who had resigned.

The meeting terminated with a vote of thanks to the Chamber of Commerce for the use of their room.

Research Laboratories,
Dartonfield,
Agalawatta, May 6, 1941.

4——J. N. A 3090 (4/41)

ANIMAL DISEASE RETURN FOR THE MONTH ENDED APRIL, 1941

Province, &c.	Disease	No. of Cases up to date since Jan. 1941	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Foot and mouth disease	1	1	—	—	1	—
	Piroplasmosis	1	—	—	1	—	—
	Rabies	9	1	4	—	—	5
Colombo Municipality	Foot and mouth disease	1	1	—	1	—	—
	Rabies	16	4	16	—	—	—
	Haemorrhagic Septicaemia	1	—	—	1	—	—
Cattle Quarantine Station	Anthrax	12	6	12	—	—	—
Central	Foot and mouth disease	2	—	—	2	—	—
	Rabies	33	5	6	—	—	27
	Piroplasmosis	1	1	—	1	—	—
	Bovine Tuberculosis	6	—	—	—	—	6
Southern	Foot-and-mouth disease	43	—	2	41	—	—
	Rabies	8	3	—	—	—	8
Northern	Foot-and-mouth disease	238	60	—	238	—	—
Eastern	Foot-and-mouth disease	65	42	4	58	3	—
	Rabies	4	—	—	—	—	4
North-Western	Anthrax	18	—	18	—	—	—
	Rabies	5	2	—	—	—	5
	Contagious Mange	8	—	1	7	—	—
North-Central	Haemorrhagic Septicaemia	43	—	43	—	—	—
Sabaragamuwa	Rabies	3	1	3	—	—	—
	Piroplasmosis	4	1	—	4	—	—

Department of Agriculture,
Peradeniya, May 21, 1941.

M. CRAWFORD,
Deputy Director (Animal Husbandry) and
Government Veterinary Surgeon.

METEOROLOGICAL REPORT, APRIL, 1941

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Agalawatta ..	90·2	+1·1	75·3	+1·7	78	95	5·1	11·85	19	—
Anuradhapura ..	92·6	+1·4	76·6	+2·1	69	93	6·0	6·30	11	+ 0·44
Badulla ..	85·4	+1·4	68·8	+2·6	72	95	5·6	7·55	14	+ 1·13
Batticaloa ..	88·5	+0·8	78·8	+2·2	75	89	5·2	3·74	8	+ 1·99
Colombo ..	89·4	+1·7	77·2	+1·4	72	91	7·0	7·93	17	— 0·95
Diyatalawa ..	78·8	+1·0	62·7	+2·5	76	92	6·4	6·58	16	+ 1·34
Galle ..	87·2	+1·0	78·8	+2·2	80	89	5·8	11·45	21	+ 2·67
Hakgala ..	74·8	+0·6	57·2	+2·4	82	92	6·4	11·26	19	+ 4·12
Hambantota ..	88·8	+1·2	78·4	+2·2	77	89	5·4	2·02	9	— 1·29
Jaffna ..	90·4	+0·9	81·3	+1·3	76	85	5·3	3·63	8	+ 2·14
Kandy ..	89·9	+2·0	72·3	+2·4	72	92	6·9	4·91	12	— 1·32
Kurunegala ..	92·4	+1·4	76·4	+1·9	69	93	6·2	10·94	13	+ 1·49
Lunuwila ..	90·7	+2·1	77·5	+2·1	72	95	6·1	9·15	13	—
Mannar ..	90·3	—0·4	79·9	+2·0	74	87	6·3	5·00	5	+ 1·87
Nuwara Eliya ..	73·2	+1·8	52·2	+2·7	74	94	7·6	5·71	17	+ 1·05
Puttalam ..	91·5	+2·3	77·3	+1·4	74	93	6·1	2·97	9	— 1·92
Ratnapura ..	92·1	+1·1	76·4	+2·6	78	91	5·4	10·42	20	— 0·82
Talawakele ..	79·0	+1·6	59·1	+1·3	76	91	6·2	9·68	17	—
Trincomalee ..	89·8	+0·9	79·5	+1·9	72	89	5·1	4·10	8	+ 2·11

The rainfall for April was rather irregularly distributed on either side of average, but, on the whole, excesses predominated. Deficits were generally confined to the western half of the island.

The largest excesses were 8·34 inches at Chadaiyantalavai, 7·86 inches at Dyraaba, and 7·41 inches each at Helboda and Batalagodawewa, while the largest deficits were 6·56 inches at Hiniduma, 6·40 inches at Matugama and 6·12 inches at Ambanpitiya.

The highest monthly totals were 19·34 inches at Udahena, 19·23 inches at Conical Hill and 18·78 inches at Lemastota, while about a dozen other stations, the majority in the south-west or in the southern foot-hills, also recorded totals of over 15 inches. Only 5 stations received less than 2 inches of rain for the month. There were no nil returns.

There were altogether 9 daily falls of 5 inches and over reported during April, the majority of them on the 22nd. The largest was 8·38 inches at Galagoda on the 3rd.

The bulk of the rain occurred during the period 4th-5th, and 8th-15th. The second half of the month was comparatively dry, the only noteworthy wet day being the 22nd., when moderately heavy rain occurred in the south-west particularly on the west and south-west coasts. Local thunderstorm activity was fairly well in evidence, and accounted for nearly the whole of the rain.

Temperatures were again above average. The highest shade temperature recorded was 96·1° at Trincomalee on the 29th, while the lowest temperature was 43·4° at Nuwara Eliya on the 20th. Humidity was above average by day, and generally about average by night, while cloud amounts were in excess. Surface winds were above normal strength, direction being variable.

D. T. E. DASSANAYAKE,
Superintendent, Observatory.